POWER PLANT ENGINEERING

Trade Mark, Reg. U. S. Pat. Office

VOL. XXVI CHICAGO, FEBRUARY 1, 1922 No. 3

Curing a Sick Plant

A DETAILED ACCOUNT OF CHANGES MADE AT THE WHITNEY PLANT NO. 2 OF THE OWENS BOTTLE CO. TOGETHER WITH A DESCRIPTION OF THE ACCEPTANCE TEST. BY FRANK C. VOGAN

DO YOU REMEMBER, way back when you were a kid, how you would stand by the hour watching a carrousel go around and around? How wonderful it all seemed and how mysterious? There is a certain amount of boyish fascination in things in motion that is never outgrown.

While it is doubtful that many reading this article have had an opportunity to watch the process of blowing glass bottles by machinery there are few who, if the opportunity presented itself, could witness the process without a hankering to go back and stay longer. The big automatic machine strongly recalls childhood impressions of the merry-go-round. So many things happen rapidly and at the same time that analysis for an instant is defied. The dropping of the bottles from the molds, the roar of the furnaces, and the rhythm of the machine completely charm the observer.

These machines with their wonderfully complex motions have been perfected to such a degree that no trouble is experienced in operating them with unskilled labor. The entire system, of which the bottle making unit is only a contributing part, runs the day through with minimum loss of the finished product.

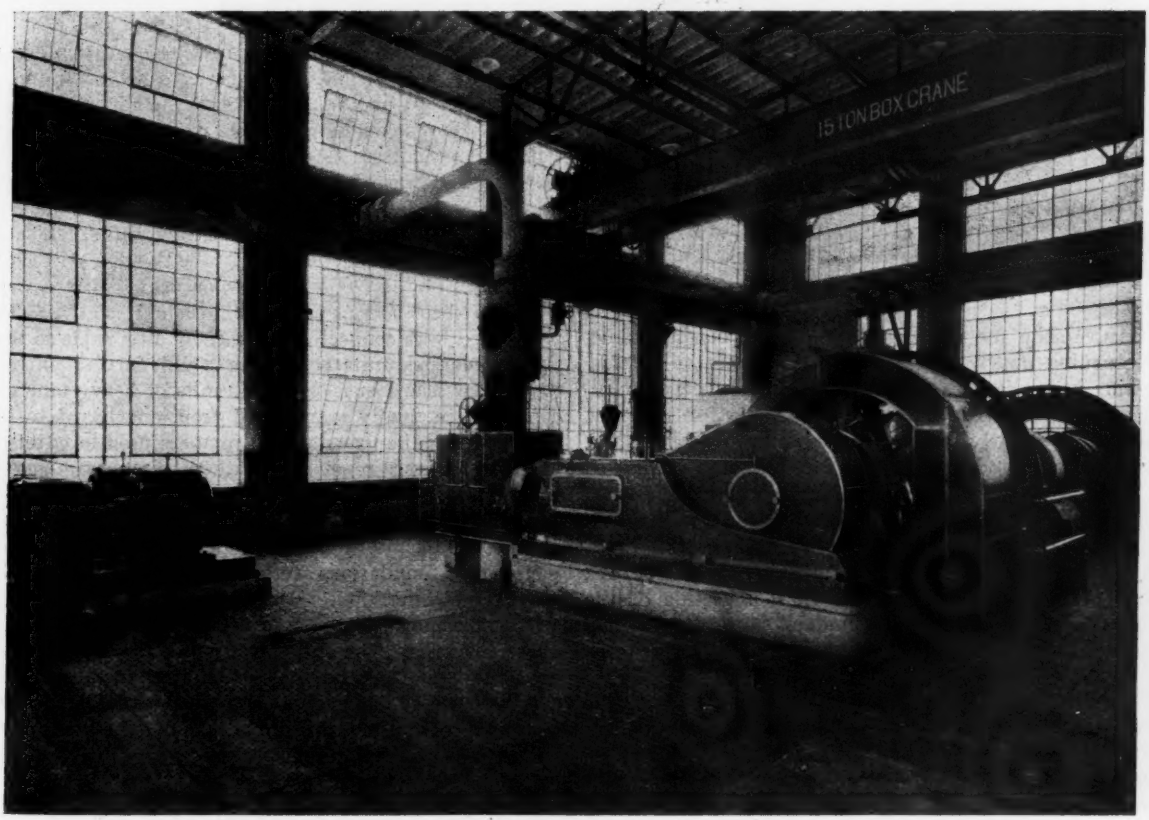

FIG. 1. GENERAL VIEW OF ENGINE ROOM

Of the industries requiring a continuous and reliable power supply, few are more exacting than the plant in

which bottles are made by the automatic process. These factories run 24 hr. a day and are in continuous operation six days a week. One would infer from the lack of Sunday operation that there is a considerable reduction in the plant load on the seventh day. This assumption is not correct, as enough power must be generated at all times to furnish both cooling and heating for the furnaces. The outside walls of the melting pots must be chilled and the pots of glass must be kept molten at all times.

Power Requirements

The consumption of power in the glass plant is divided into several distinct portions. Groups of motors operate variously the revolving mold machines, the revolving glass pots, the tempering apparatus and the associated conveyor systems in the bottle factory. Outside of the immediate process of making the bottles are other groups of motors that drive conveyors for charging the furnaces, conveyors for taking the broken glass away from the bottle machines, and traveling belts for carrying the raw materials about the mixing machines. Like other process, the up-to-date glass factory has an

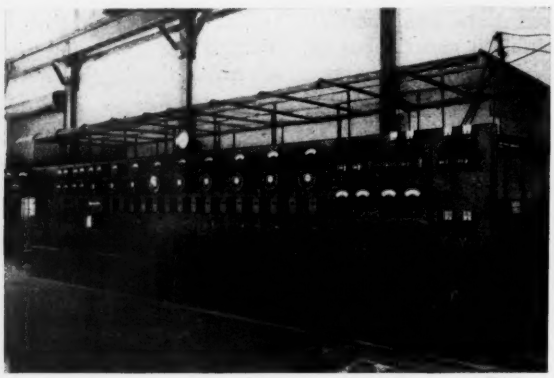

FIG. 2. MAIN SWITCHBOARD

extensive shop for making and repairing machines and for turning out the dies used in molding the bottles. Again, power is consumed in the packing department where wooden boxes and crates are made for shipping the glass. Nearly all power requirements about the glass works of today are cared for by motor drive.

Most glass plants make their own electric power. This condition is reasonable. Glass plants through necessity have grown up in a sort of self supporting way, they rarely look to the outside for help. Then, too, the glass industry is rooted deeply in that section of the country where there is an abundant supply of natural gas. Not alone for heating does the glass maker use gas, but for the generation of power. Where a good quality of natural gas is to be had, the dual use of the fuel seems to meet with satisfaction. In the development of the glass making business, new plants have been established in sections of the country where natural gas is not found, but when this condition has been met, the glass maker has gone to work and made gas. Making gas for the heating of furnaces works out fairly well, but some have gone farther and have tried to use the producer gas for the driving of engines. In this, some may have succeeded, but others most emphatically have failed. The use of producer gas is not recommended for the operation of internal combustion engines which are associated with alternating current generators. This is especially true in cases where continuous and reliable service is demanded.

Much trouble experienced with the use of producer gas for engines is due to the lack of proper cleaning of the fuel. Tars are carried over into the engines, which results in serious backfiring. When the engines backfire, the interchange of current between generators imposes severe strain on the metering equipment which soon destroys accuracy. A slug of tar will often gum up the ignition system; this condition generally shuts the station down. It is a peculiar fact, that once a plant is attacked with engine trouble resulting from poor gas, the condition rapidly becomes chronic.

The foregoing merely touches on some of the pertinent facts which led one of the largest bottle blowing factories in the eastern states totally to revise its plant. This plant was originally operated with producer gas. Current was generated three phase, 60 cycles and at 450 v. by three 312-kv.a. revolving field generators each directly connected to a vertical gas engine. The glass company under discussion has in operation some 12 plants, all of which are gas driven, but natural gas is used in all of them. When it was decided that some drastic steps had to be taken to correct the faults of this eastern plant, steam driven units were of course frowned upon; however, the steam plant got the final decision.

In revising the plant, an interesting condition arose. As already stated, continuous service must be supplied this type of plant; this meant that in changing from operation by gas engines to steam engines no shut-down would be permitted. As a matter of record, the complete change was made without shut-down or mishap. One gas engine unit was first removed to accommodate the placing of the first of two steam units. A new switchboard was immediately installed and, on its completion, all of the feeder circuits on the old board were transferred to the new one. Then the old board and the new board were connected together by a tie cable so that the gas engine units remaining could furnish current to the new board bus. Eight circuits of heavy multiple copper were finally transferred from one board to the other. After the transfer, the jumpers used in effecting the transfer were removed. With the first steam engine in operation, the other two gas engines were speedily removed to make way for the placing of the second steam engine. It is interesting to note that some of the old gas engine foundations were blasted out while the station was in operation. Forty per cent dynamite along with extreme caution worked wonders in the removal of these obstacles. The entire load of the station was carried for 9 mo. on the first steam unit installed. The performance of this engine has been remarkable: 24 hr. a day, and for 9 mo. this unit has functioned with a 20-min. stop each week for inspection.

The new power plant is provided with steam by a battery of six 250-hp. water-tube Heine boilers, worked at 150 lb. pressure. This boiler pressure provides 145 lb. at the engines which are some 200 ft. removed from the boiler house.

The new equipment in the power station is summed up in the following paragraph and is further shown in the accompanying cuts. The engines are both of Ball

make, of the four valve type and operate at 164 r.p.m. The smaller of the units is a 24 by 30-in. simple unit rated at 800 hp. and is directly connected to a Burke revolving field type generator of 780-kv.a. capacity. The larger engine is a cross compound 27 by 30-in. and 27 by 42-in. which is rated at 1260 hp. and is directly connected with a Burke revolving field type generator having a capacity of 969 kv.a. The generators are both 450 v. three-phase, 60-cycle machines and each is provided with a belt driven exciter of 22-kw. capacity operated from the main engine shafts. To obtain constant voltage, the exciters are handled by a G. E. Tirrill voltage regulator placed on the main switchboard. Rheostats controlling the main generator fields are located in the basement below the engine room and are remotely operated by Cutler Hammer solenoid equipment. For the production of direct current, a small amount of which is used about the plant, two 75-kw. motor-generator sets are installed in the engine room.

The switchboard controlling the new installation is a feature in this project. The board itself is of black Munson slate, finished in oil and contains all of the necessary equipment for the control of the two steam driven generators, eight feeder circuits and the motor-generator sets. All feeders are provided with oil circuit breakers of Condit make, and further protected with relays of Condit type A. To facilitate in making tests and inspections of the metering equipment on the board, the bottom of each switchboard panel is supplied with testing clips and terminals for potential and current. A very complete test made in this plant a few months ago revealed some very interesting figures. The test was conducted in accordance with the rules and regulations of the A. S. M. E. and proved that with a load of 742 kw., current was being delivered to the switchboard at an overall cost of 0.016,72c. per kw.-hr.

It has been stated that this glass factory was afflicted with a sick gas engine power plant. They had orders to fill, and had machinery to produce their wares, but the current required to put real life into their investment was an unreliable performer. Everything reasonable was grasped at to save the balky gas engine plant, but its frightful temperamentality was beyond response.

At this juncture, the substitution of the steam units was proposed. This was rather bitter medicine, bitter indeed to think of abandoning the gas engines that had hardly seen two years of real service. But drastic steps had to be taken as production had begun to show signs of weakness and after much argument and coaxing, the management finally decided to try the production of power by the steam method.

One can scarcely blame these people for the show-me attitude they assumed. Truly, it was to their interest that the revised plant perform with success; but somehow, they could not conceal the ever present "I told you so" that now had become a part of them.

The business of putting in the steam plant could not be done on a say-so. Contracts had to be made, specifications and plans had to be drawn, and above all, the plant that had given 2 yr. of trouble had to be cured in as many months.

You have probably noticed that a sick man can make a strong will, but it takes the management of a sick power plant to dictate a strong contract. Only an experienced engineer can really appreciate and survive such an agreement.

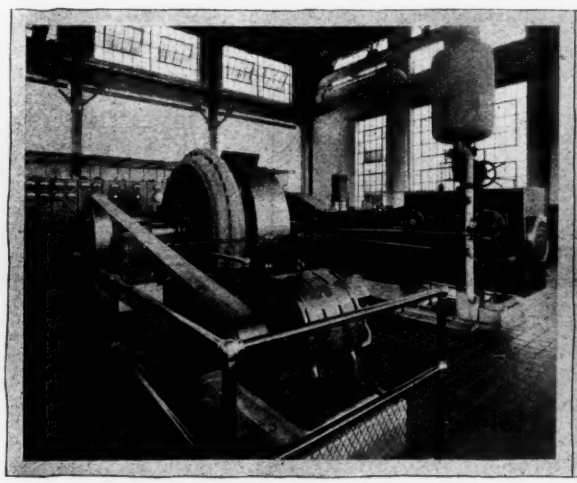

FIG. 3. THE SMALL 800 HP. SINGLE UNIT

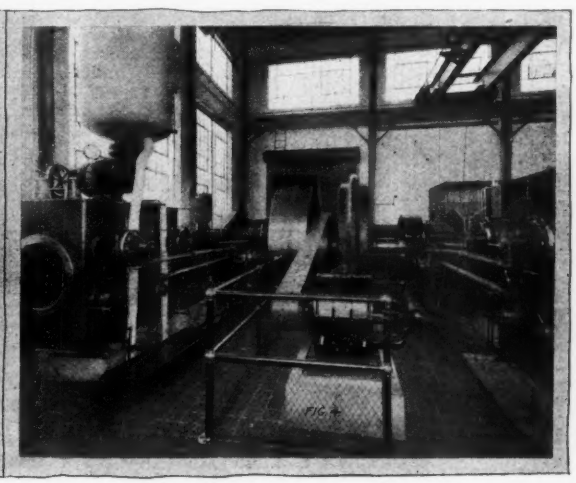

FIG. 4. THE LARGE 1200 HP. CROSS COMPOUND UNIT

THE CONTRACT; REASONS FOR THE TEST

THE CONTRACT that governed the installation of the new steam power plant was tightly drawn and explicitly worded. One can readily understand that the disappointments wrought by the gas engine plant would naturally be carefully guarded against in making the change. Some of the outstanding features of the contract for the new work clearly indicated that reliability and economy were to be attained but not without reckoning the cost. As a rule, where guarantees are exacted, they must be paid for. That this industrial was willing to spend to obtain results is definitely shown in the character of equipment purchased—but they had bought equipment before, and this time we find them seeking performance. In the contract definite terms were dictated. Prominent features of the agreement told not only what was expected, but further, how and in what manner the results were to be decided. All guarantees were based on the performance of the larger of the two

steam units, or the compound engine, and subsequent auxiliary apparatus when completely installed and in operation. Again, when the new plant was running, it was to furnish reliable and dependable power to the factory at a cost not to exceed one and 81/100 c. per kw.-hr. The cost of current, among other items, was to be based on the best grade of bituminous coal containing not less than 14,000 B.t.u. per lb. and at a cost of $6 a ton. Certain fixed charges, an attribute of any power project, were of course to be considered. A monthly allowance of $2500 for interest, depreciation and insurance, along with an item of $900 monthly for the wages of firemen and engineers, constituted a deduction as "fixed charges" in the agreement.

To establish a basis for the cost of current it was agreed to figure on a monthly output of 500,000 kw.-hr., this being the consumption of the plant under normal or average conditions. The consumption mentioned, for the cycle of operation in this case, imposed a constant generating demand of about 700 kw. on the equipment. By the terms of the contract, the cost of operating the steam air compressors and other auxiliaries, not including the boiler feed pumps, was not to be charged to the cost of making power.

Finally, for the purpose of determining whether all of the foregoing requirements had been satisfactorily fulfilled, a test was to be made on the entire revised plant, the steam to be used through the compound engine in determining the results.

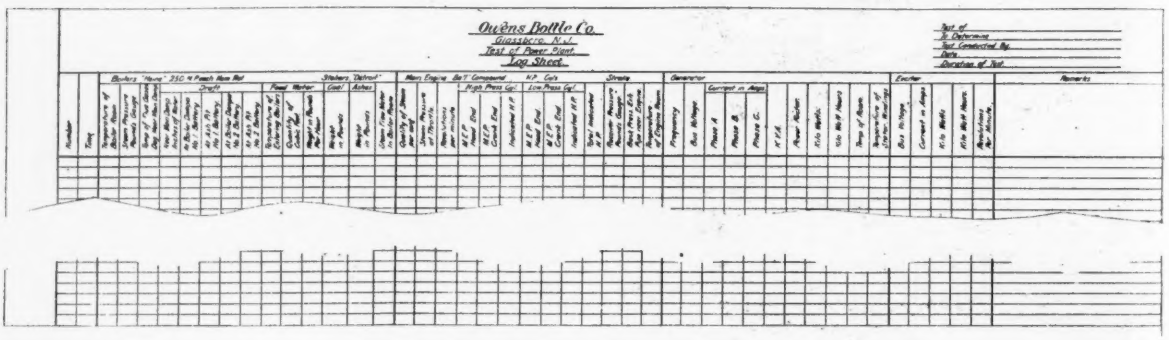

FIG. 5. LOG SHEET EMPLOYED IN THE TEST

Remarks Concerning Tests in General

Tests performed to develop the economy of the power making process, or to prove its costs, must always be cognizant of certain factors. All tests of this kind should be made under normal operating conditions. Results should not be striven for which are likely impossible to attain under average circumstances, or, that are beyond the ability of the everyday operating crew. Selfish advantage in availing oneself of each and every opportunity to boost the results of a test to show phenomenal economies may be far reaching and prove disastrous. Many operating engineers have suffered unjust criticism for no greater cause and others have lost their positions because of this foolish practice. Due regard should be paid the maddening circumstances that, at times, beset the 24-hr. operating cycle in a plant. Being decent in making allowances for such occurrences will earn respect. While a dirty and untidy power plant is to be condemned, the practice of "dolling" a plant for testing purposes only is likewise to be frowned upon. A power plant, for honest results, must be tried "as is." All the adjusting, polishing and cleaning in the world applied once in a lifetime affords little hope for limping kilowatts.

Two essentials in making plant tests must be given careful attention—men and instruments. The men employed for this class of work must be well grounded in their specialized departments of the endeavor, and must be experienced in their respective duties. Moreover, a complete test cannot be made with only a handful of men. Where insufficient observers are provided for tests, disputes generally follow in the wake of the trial. It is excellent practice to place the responsibility of an entire test in the hands of one chief mechanical engineer. This man, not being permanently located at any specific post in the plant, can circulate among the observers and carefully watch all of their work at convenient intervals. If during the test, conditions arise that require immediate attention or comment on the part of those concerned, the chief engineer mentioned becomes the logical point of contact between the observers and the operating force in the plant. This man is in position to take action without disturbing any of the observers who are busy with their respective duties and records.

Schedule—Distribution of Observers

The observers were assigned to the various posts in the following manner:

1—Chief Mechanical Engineer—Unassigned.

2—Electrical Engineers—Switchboard and generating equipment.

2—Mechanical Engineers—Engine room, indicators and calorimeters.

2—Mechanical Engineers—Boiler room, weighing water.

2—Mechanical Engineers—Boiler room, weighing coal.

2—Mechanical Engineers—Boiler room, draft gages, pyrometers, and flue gas equipment.

The advantage of doubling the number of men assigned to each post is that instantaneous checking of all readings is possible, further, when reliefs are necessary, no confusion results as the relief man is instantly available.

It has been found well to make readings of the various instruments and devices used in this class of testing

at intervals not exceeding 15-min. periods. The total number of readings to be recorded is considerable when one is reminded that such tests cover 24 hr. of operation. Before the test is actually commenced, the watches or timepieces of all the observers should be accurately synchronized as it must be remembered that many of the points of observation are remote. Each crew of observers should be provided with several log sheets similar to the one shown in Fig. 5. It will be noticed that the first two columns are respectively marked Number and Time. The purpose of this double identification is to furnish a dual check on all records when the final sheet is made up and the results are all computed.

The instruments used in a test of this character are, no doubt, familiar to most operating engineers. Figure 6 shows in diagram the approximate locations of the various devices employed. For filling in the electrical portion of the log record, the instruments on the station switchboard were used and observed.

The Generating Equipment

The first part of this article dealt in a general way with the generating units, but this meagre description of the power producing machines is not sufficient. In making this review, the writer is aware that the up-to-date plant man is forever making comparisons with things that the other fellow is doing; therefore a more complete description is in order.

The Compound Engine

For the larger of the two generating units, a horizontal side crank, cross compound, heavy duty pattern, Corliss four valve non-releasing gear, automatic cutoff, self oiling engine was selected and installed. This engine was furnished with shaft arranged for direct connection to the larger of the two generators.

Data

High pressure cylinder	27-in. dia.
Low pressure cylinder	42-in. dia.
Stroke	30 in.
R.p.m.	164
I.hp. rating	1260
Steam supply	10 in.
Exhaust	16 in.
Wheel diameter	110 in.
Wheel weight	28,000 lb.
Main bearing	13 in. diameter by 26 in. long
Crankpin	9 in. diameter by 6.5 in. long
Crosshead pin	7 in. diameter by 7.5 in. long
Piston rod	4⅜ in. dia.
Crosshead shoes	11.5 in. by 19 in.
Floor space	25 ft. long by 20 ft. wide
Shipping weight of engine	145,000 lb.

Steam pressure at the throttle specified as 150 lb. with 5 lb. back pressure.

The Simple Engine

For the smaller of the two generating units, a horizontal side crank engine, single cylinder heavy duty pattern, Corliss four-valve, non-releasing gear, automatic cutoff self-oiling unit was installed. The smaller unit, like the large one, was also provided with shaft for the direct mounting of the rotor of the generator on it; but in addition, this engine was supplied with an outboard bearing.

Data

High pressure cylinder	24 in. dia.
Stroke	30 in. dia.
R.p.m.	164
I. hp. rating	800
Steam supply	8 in. dia.
Exhaust	12 in. dia.
Wheel diameter	110 in.
Wheel weight	24,000 lb.
Main bearing	12.5 in. diameter by 24 in. long
Outboard bearing	11.5 in. diameter by 21 in. long
Crankpin	9 in. diameter by 6.5 in. long
Crosshead pin	7 in. diameter by 7.5 in. long
Piston rod	4⅜ in. dia.
Crosshead shoes	11.5 in. by 19 in.
Floor space	24 ft. long by 15.5 ft. wide
Shipping weight	84,000 lb.

Steam pressure at the throttle specified as 150 lb. with 5 lb. back pressure.

Economies of the Steam Units

In the proposal submitted by the engine builders, it was specified that, with dry steam at the throttle at 150 lb. and with free exhaust, the guaranteed steam

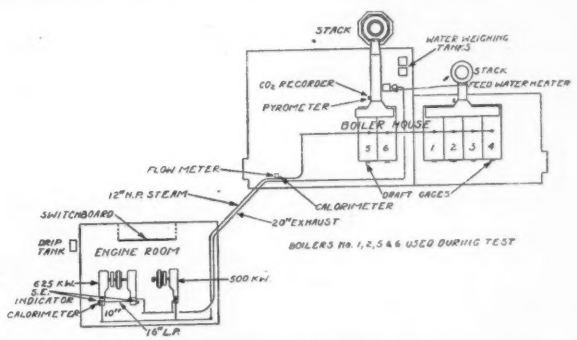

FIG. 6. DIAGRAM SHOWING THE APPROXIMATE LOCATION OF THE VARIOUS INSTRUMENTS

consumption per indicated horsepower would not exceed the figures shown in the appended schedule.

The Compound Engine.	The Simple Engine.
½ load ..... 19.9 lb.	½ load ..... 21.6 lb.
¾ load ..... 18.5 lb.	¾ load ..... 21.1 lb.
Full load ..... 18.4 lb. (1430 hp.)	Full load ..... 21.4 lb. (850 hp.)

The Generators

A peculiar instance arose when the purchase of the electrical units was to be made. The manager of this particular plant flatly refused to have anything to do with the commercial ratings of alternating current machines. A "kv.a." he had often heard about, but he balked at having any such things in his plant if he could possibly help it. The reader will note that in giving the detailed ratings of the generators, double ones have been applied. This was done to meet the foregoing situation with as much grace and courtesy as possible, but with no discredit to the plant manager. Glassblowers make glass, not power factors and kv.a.'s, of this we are fully aware. Moreover, glassblowers require power in unlimited quantities and refuse to be pained with the ordinary overload ratings of commer-

cial machines. One will note in the temperature ratings given, a wise ear has been afforded this weakness. The writer thought it best to preface the next paragraph with these remarks; it may save criticism.

Generator Ratings

As explained, the generators had to be given two ratings. The make-up of the machines is almost identical, except that one is of larger capacity than the other. Both are of the revolving field type, having their rotors directly mounted on the respective engine shafts. The machines are both provided with belted exciters of the same frame sizes and have similar direct current outputs of 22 kw., at 680 r.p.m.

Large generator

Rated capacity—625 kw. at 80 per cent power factor, temperature limit 35 deg.

Overload capacity—775 kw. at 80 per cent power factor, temperature limit 55 deg.

Efficiencies—½ load 92.1
¾ load 93.75
Full load 94.5

Approximate weight, 25,000 lb.

Small generator

Rated capacity—500 kw. at 80 per cent power factor, temperature limit 35 deg.

Overload capacity—625 kw. at 80 per cent power factor, temperature limit 55 deg.

Efficiencies—½ load 91.7
¾ load 93.3
Full load 93.7

Approximate weight, 22,600 lb.

In the conduct of the test, the feed water was measured in two calibrated tanks, having an average capacity of 1226 lb. each. These were filled by a tank pump and emptied into a reservoir beneath, which supplied the boiler feed pumps.

The indicator driving rig and piping on the engine was that furnished as a part of the permanent engine equipment. The indicator used on the high pressure cylinder of the compound engine was an outside spring instrument, 80-lb. scale, made by the American Steam Gauge & Valve Co. The instrument used on the low pressure side was a Crosby indicator, inside spring type, 20-lb. scale. Both indicators were attached to three-way cocks.

To determine the amount of moisture in the steam at the throttle valve, a Carpenter calorimeter was employed. At the flow meter, a second calorimeter was established; this one, however, was of the A. S. M. E. type. Both calorimeters discharged steam into the air.

A Crane tilt trap, draining the separator of the engine supply, discharged into a tank on a platform scale. The tilt trap draining the intermediate receiver of the compound engine was disregarded and discharged to waste.

For ascertaining the temperature of the flues, pyrometers were used and flue gas analysis was made with Franklin apparatus.

For handling the coal, wheelbarrows were employed which, when filled, were successively placed on Howe scales located conveniently for the purpose. After passing the scales and having the weight tabulated, the barrows were dumped into the stoker feeders as occasion demanded. During the test, samples of the coal used were taken from each barrow and the whole thoroughly mixed and quartered down until a 5-lb. sample remained. This was given to a chemist for analysis, the result of which is later recorded.

At the conclusion of the test, all the ashes were weighed in the wheelbarrows used previously for coal and on the same scales.

The steam consumption of the compound engine under test was measured by a Bailey flow meter, this record being observed simultaneously with the synchronized making of the indicator cards on the engine.

The characteristics of the generator and its exciter were determined by the use of thermometers so placed to record the maximum rise in temperature resulting in the embedded windings of the respective machines.

Results

In what follows, the results of a consecutive 8-hr. period taken during the 24-hr. run are analyzed and tabulated. For the convenience of the reader, the various items are numbered so that cross reference is facilitated.

(1) The total amount of coal fired was 39,716 lb. From this item must be deducted the amount of unburned fuel which constituted 24.2 per cent of 8999 lb. of ash, making the net coal item equal to 39,716 minus 2178 or 37,538 lb.

(2) The water for the boilers totaled 252 tanks at 1226 lb. each, or 308,952 lb. Due to leakage of valves in the water supply lines, it was agreed to add a total of 3675 lb. to take care of the water wasted. This leakage was obtained by a supplementary test. The total amount of water handled was therefore 308,952 plus 3675, or 312,627 lb.

(3) To ascertain the evaporation per pound of coal fired, the total amount of water was divided by the total amount of coal fired, or 312,627 divided by 39,716, which gives 7.874 lb.

(4) To ascertain the evaporation per pound of coal burned, the total amount of water was divided by the total amount of coal burned, or, 312,627 divided by 37,538, which gives 8.328 lb.

(5) The cost of coal fired, per ton, was arrived at as follows. By reference to a preceding paragraph, it will be noted that coal having a B.t.u. value of 14,000 was stipulated, further the coal was to cost six dollars per ton. Neither of these specified values were sustained, therefore, because of the modifications mentioned, corrections were made in figuring these items. The cost of coal as fired, per ton, was found by multiplying the B.t.u. value of the coal as used, by the stipulated contract price of the fuel per ton and then dividing this product by the stipulated B.t.u. value as given in the contract. In actual figures (12,959 by 6.00) divided by 14,000 gave $5.55 as the cost of the coal per ton with the corrections made. The value 12,959 was the B.t.u. value obtained from the analysis of the fuel.

(6) To find the cost of the coal fired, that is the total cost of the fuel used, the following method was pursued. The total number of pounds of coal used (item 1) was multiplied by the corrected price of the coal per ton (item 5) and the product of these figures was then divided by the number of pounds to the ton. In the actual figures of the test (39,716 times 5.55), divided by 2000 gave $110.26.

(7) The cost of 1000 lb. of steam was obtained by dividing the cost of the coal (item 6) by the total amount of water delivered to the boilers (item 2). From the final sheets of the trial the figures taken are, 110.26 divided by 312.63, which gave $0.353.

(8) The equivalent evaporation was derived from the product of item No. 4 and the factor of evaporation obtained for 150-lb. pressure and 200 deg. feed water, or, the equivalent evaporation considering the coal as burned was 8.328 times 1.0584, or 8.82 lb.

(9) The boiler efficiency, considering the coal burned, was found by the rule that states the actual equivalent evaporation per pound of coal burned must be multiplied by 970.4, and that this result must be divided by the B.t.u. value of the fuel. The test figures for this item showed (970.4 times 8.82) divided by 12,959 equaled 66.2 per cent; see item 8.

(10) The equivalent evaporation derived from the product of item 3 and the factor of evaporation obtained with 150 lb. pressure and 200 deg. feed water gave the value of equivalent evaporation for coal as fired. In figures this was (7.874 times 1.0584) or 8.32 lb.

(11) The boiler and grate efficiency, considering the coal as fired, was found by multiplying together the factor 970.4 and 8.32, the figure giving the evaporation per pound of coal burned, item 4. The product of these two numbers is then divided by the actual B.t.u. value of the coal used, or 12,959, which gave 62.3 per cent.

One will observe that the boiler efficiency as represented in item 9 is greater than the combined efficiency of the boiler and grate as shown in item 11. This was because of the raw coal that passed through the grates unconsumed.

(12) The total pounds of steam passing through the flow meter was recorded as 29,926. This item was subjected to corrections for pressure and moisture, the total was reduced to 28,990, and for calibration, finally to 21,190 lb.

The coal per hour was obtained by dividing the total number of pounds of steam by the product of the figure representing the evaporation per pound of coal fired, and the figure showing the number of pounds to the ton. From the test sheets, 21,190 is divided by (7.874 times 2000) which gave 1.345 tons.

The cost of coal per hour was got by multiplying together items 5 and 12. In figures this was shown as 5.55 times 1.345, or $7.46.

(13) In the engine builders' guarantee, 150 lb. pressure at the throttle was specified. During the test, this pressure could not be maintained; 145 lb. was the best that was reached. This condition compelled a correction allowance for the low pressure that prevailed. For the high pressure cylinder, this revision added 30.25 hp. and for the low pressure cylinder, 43.35 hp., or a total of 46.7 kw., with generator efficiency considered.

The indicated generator load during the test was recorded as 695.3 kw. It will be seen that this indicated load must be corrected by the pressure allowance of 46.7, which brought the electrical demand up to 742.0 kw. per hr.

(14) The cost per kilowatt-hour was then obtained by dividing the hourly coal charge, item No. 12 by the hourly generating demand, item No. 13, or 7.46 divided by 7.42. This rendered a cost of $0.01005.

This cost had to be modified, because by the terms of the contract, the fixed charges had to be considered.

For depreciation and interest, insurance, etc., $2450.76 was stipulated, and for wages of firemen, $900 was allowed. The total of these items, $3350.76, was of course applicable to the monthly output on which the contract was based. The fixed charges per hour were then equal to the total kilowatt-hours, 500,000, divided by the fixed charges or $0.00672.

The total cost per kilowatt-hour of current at the main switchboard was equal to the sum of the two items representing the coal charge per kilowatt-hour and the fixed charge per kilowatt-hour. By the addition of these two items it is proven that the total cost of current, per kw.-hr., ready for delivery at the board, was not in excess of $.01005 plus $.00672 or $0.01677, much inside of the contract guarantee.

As a matter of interest, the analysis of the coal sample is added.

Coal Analysis

The following analysis of the fuel used in the test was made and certified by the firm of E. L. Conwell & Co., Philadelphia.

Moisture	1.70 per cent
Volatile matter	31.18 per cent
Fixed carbon	49.49 per cent
Ash	17.63 per cent
Sulphur	0.91 per cent
B.t.u.	12,959
Fusing point of ash	= 2370 deg.

The entire revision of the plant was made under the supervision and direction of the Ballinger Co. of Philadelphia, who also arranged and supplied the crew of engineers who conducted the test.

Too Busy to Inform*

By W. F. Schaphorst

IT IS not uncommon for manufacturers to do things that cannot be explained, but why any of them should refuse to give needed information which would "boost" their product is beyond the writer.

I recently received a letter from a man employed by a prominent manufacturer, for instance, who said he "didn't have time" to give me data for which I have several times asked. He stated that after two or three months he "might" be able to attend to my wants.

Doesn't it seem rather strange for manufacturers to write like that? It's a fact, nevertheless. I can find no plausible excuse for putting off matters of this kind for two months at any time, busy or not. By means of printer's ink, complete information can be given to millions of people, let alone telling only one person.

I informed the above manufacturer that I am not in the market for their machinery personally, but the data I wished to gather would be helpful to them in their future sales in a certain field. I wrote to other manufacturers at the same time—some of them bigger than this one and some smaller—and they all responded willingly.

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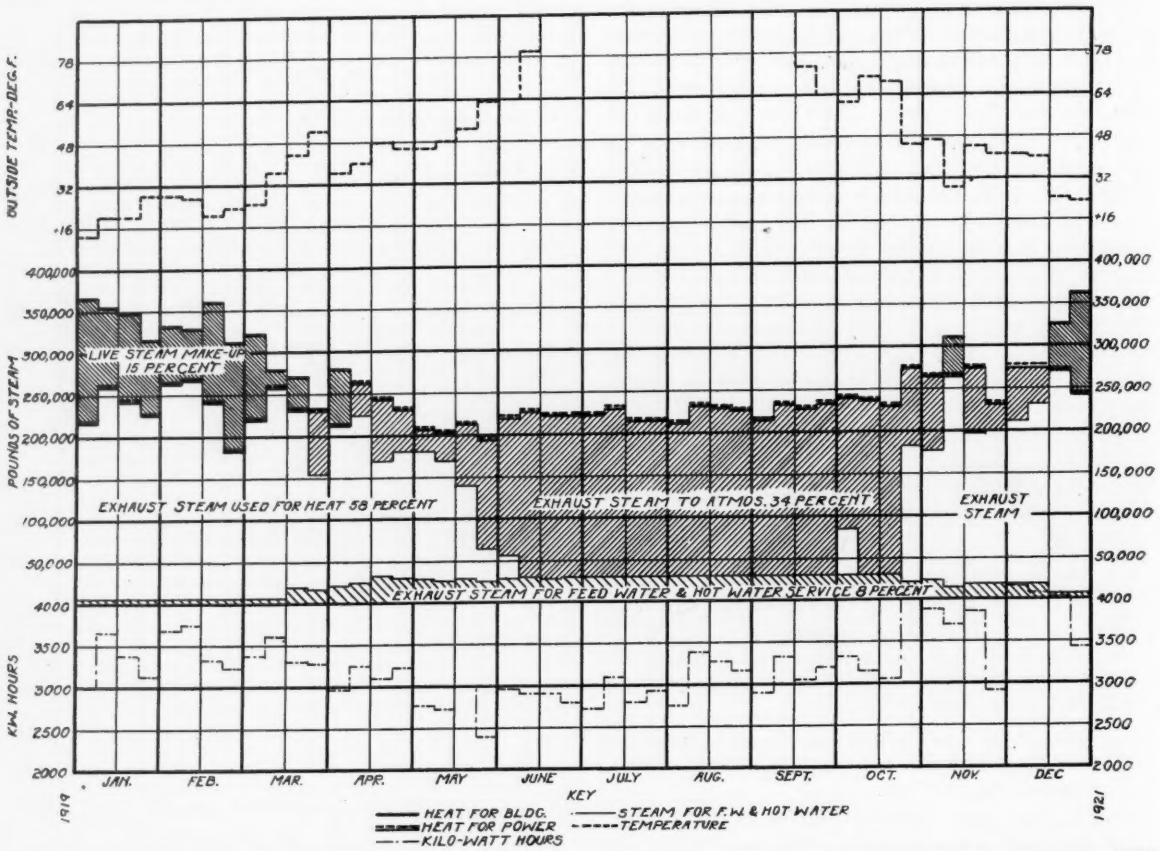
Selection of Power Service for Non-Industrial Buildings

ILLUSTRATING GRAPHICALLY THE HEAT AND POWER DEMANDS OF AN OFFICE BUILDING. BY J. O. BATZER

SELECTION OF suitable power service for non-industrial buildings usually requires considerable study of costs and operating requirements if a correct solution of the problem is to be arrived at. Where industrial processes demand the use of low pressure steam, an isolated plant is usually the obvious solution, but if it is evident that a part of the exhaust steam is to be discharged to the atmosphere during certain periods of the year, central station service may seem to be the most logical plan to the owner unless the engineer or architect is prepared to be on the job with comparative facts and figures to prove the contrary.



HEAT, POWER, AND TEMPERATURE CONDITIONS PREVAILING IN A 16-STORY OFFICE BUILDING DURING THE YEAR 1920

The usual technical data established in the architect's office for calculation of plant requirements must be considered rather incomplete upon which to base a closer estimate of operating cost, and his organization does not always command the necessary knowledge of the more intimate details of plant construction and management on which success or failure of the independent service may depend. Where the architect is invested with decisive authority for the selection of central or independent service, what will be the factors governing such decision and how are these to be determined?

Looking from the operating engineer's point of view the problem resolves itself into a detailed analysis of investment cost, labor, supplies, etc., as against purchased power and heat. Under ordinary conditions the capacity of the plant will dictate the most economical course to follow.

EMPLOYMENT CONSIDERATIONS

IF THE purchase of both power and heat is first considered, what proportion of the ordinary isolated plant force will have to be retained? Aside from the prime movers in engine and boiler rooms, the auxiliary equipment is still left to demand supervision and maintenance. The heating and vacuum systems require the steamfitter and the water service needs the engineer and plumber. The elevators, motors and other equipment also demand the regular quota of electricians. Possibly the operating force could be reduced 50 per cent in this case, or one-half of the ordinary plant crew would have to be carried without any production whatsoever.

If such a plant were augmented with steam generating equipment, auxiliaries and the necessary boiler room attendants, would it be safe to assume that a larger or smaller part, as the case may be, of the annual heat bill would revert to the owner's profit account? The answer to this question undoubtedly would be in the affirmative. The efficiency rate of such a plant, if large enough,

should not fall very much below that of the local "central" station, which consists more or less of a string of abandoned isolated steam plants feeding a common system of street mains. The central's seasonal employment policy could be adopted.

Assuming that the heating demand of the building was large enough to recommend the investment of an independent boiler plant, would then the power bill warrant the further supplement of electrical equipment with its additional labor and maintenance?

The central station representative, if consulted, would probably argue hard against such a policy, while the architect or engineer would maintain that in a non-industrial establishment the relative value of the current available through the heat demand of the building, as compared to the exhaust discharged to the atmosphere during the balance of the year, should be a fair basis for such conclusion.

Any engineer who is keeping proper operating records of his plant can easily establish a reasonably correct value of this relation, and it seems obvious that a number of such data of actual performances from the different sources within the reach of the architect, should be of importance to his office as standards for use in new construction projects. A "follow up" system of the actual production, performances, maintenance cost and necessary changes or additions to the construction details of the plant should also be of value to the architect's records. The prevailing custom of terminating his interest in the plant with the final certificate would seem to deprive his organization of an actual check on his theoretical construction formulas applied to the plant.

Graphic Illustration

As it may be of interest in this discussion to observe graphically the elementary demands of a building plant and their relation to each other, the accompanying diagram was designed. The actual operating records for 1920 of a representative office building of the class mentioned before, was selected for plotting data and the temperature data, which are part of the plant record, are taken from the published observations of the local weather bureau.

This structure is 16 stories high, exposed in all directions, being surrounded by smaller buildings, and has a volume of about 3,500,000 cu. ft. Total wall area is about 153,000 sq. ft., of which 45 per cent is window surface. Forced ventilation is adopted throughout the building, this being, however, curtailed to some extent during very cold weather.

As the daily fluctuations of the load would make a diagram covering such an extended period rather cumbersome, the weekly average of the daily consumption of steam and current as metered, and temperature recorded, was selected as plotting values for the curves. The maximum 24-hr. peak load would exceed the weekly average as plotted by 40 per cent for power and 20 per cent for total steam generated. The heat reclaimed by the feed water and steam required by the hot water service were determined when no building heat was demanded, as was also the gross steam consumption per kw.-hr. To determine the heat demand at temperatures where only part of the exhaust was required, the heat loss in pounds of steam, or building constant, for each degree of temperature difference was established by analysis of the daily output under various conditions of outside temperature and building activity and may be assumed to be fairly correct.

The object of the diagram is to demonstrate as clearly as possible how great a part of the exhaust steam is utilized for building heat and also the percentage of this actually wasted to the atmosphere. Analysis of the diagram will show that the exhaust steam will begin to be drawn upon for heat at a temperature of 60 deg. F. and increase with the drop in temperature until at about the freezing point all exhaust steam available from maximum power demand is consumed. A further drop in temperature requires a corresponding make-up of live steam.

The relative percentage of the utilized and wasted exhaust steam and the live steam make-up are noted on the diagram. From the chart can also be estimated the part of the total current generated that may be considered as a by-product of the heat demand. This is close to 61 per cent.

A building of this size and exposure demands a great amount of steam for heating purpose. The movement of the air due to the forced ventilation brings calls for heat as soon as the temperature approaches the 60 deg. mark. In this connection it may be of interest to note that the movement of the air, calculated from data obtained for this purpose, proved to be closely as follows:

With outside temperature ranging from 35 deg. to 50 deg. F. the natural change of air would take place once per hour at night, 1½ times on Sundays with doors partially moving and 4½ to 5 times per hr. during office hours with ventilating system in operation. During lower temperatures, with normal wind velocity, the changes would range from 2 to 3 times per hour at night and from 6 to 8 times per hour during daytime with exhaust fans shut down. Wind velocity proved to be of greater influence than temperature variations.

When compared to other buildings of its class and capacity with all petty industrial activities excluded, the demand for power, averaging 52 per cent of the total current generated, seems rather excessive. This is due to the elaborate ventilating equipment. If this was eliminated or reduced to the usual first floor and underground requirements, the exhaust steam discharged to the atmosphere would be cut in half and reduce the heat cost correspondingly.

If the yearly performance as illustrated by the diagram is considered as a whole, the main factors governing the economy, or the choice of central or independent power, seem well defined. In the case demonstrated, the value of the 61 per cent of the total power demand obtained practically free far outweighs the 37 per cent of exhaust steam wasted to the atmosphere during the summer months, and their relative cost can easily be determined.

We all admit that waste of exhaust steam is poor economy under any circumstances, even if such waste is of advantage to the individual producers as compared to central service. From a national point of view such condition, when avoidable, is indefensible in view of our rapidly diminishing fuel resources. Millions of tons of coal could be saved annually to the country if a closer co-operation and greater regard for the common good could be established between the central station and the isolated plant.

Conceding the fact that the independent plant under certain conditions is the better investment for the owner, a partial service of the central station during the period when exhaust steam is wasted would undoubtedly prove to be of benefit to both parties as well as a great forward step in the interest of fuel conservation. Developments in this direction should be encouraged both by the architect and engineer and the central station should facilitate such intimate relationship by the smallest possible connection charge.

While remodeling for this purpose may not warrant the expenditure, in a plant of new construction such co-operation could best be provided for. The boilers should be of a graduated capacity to meet the gradually increasing heat demand with greater efficiency, and, boiler feed and some reserve equipment excepted, all auxiliaries should be electrically driven. Hot water and kindred services could be taken care of during the summer by garbage burners, either coal or oil fired. The switchboard should be designed to allow each feeder to be thrown on either central station or plant bus so that the exhaust available from the electrical current generated by the plant could always be made to balance the heat demand. With the arrival of the heatless months, the boiler plant is shut down and given a general overhauling and repairs to carry it over the next heating season. A smaller maintenance force could then be employed so as to avoid the annual change in boiler room attendants.

It will be noted from the diagram that during the times of lower temperatures the exhaust available from maximum power demand falls short about 15 per cent of meeting the total building requirements for heat. This amount of live steam has to be made up directly from the boilers without its expanding energy first being utilized for power generation. Such a condition is generally prevalent in all large building plants.

An ideal degree of economy would, indeed, prevail, if co-operation could be developed to such an extent that *all* heat was first utilized for power generation and that the excessive current, if any, could be returned to the central station.

Recent Fuel Investigations

EXPERIMENTS CONDUCTED TO DETERMINE FEASIBILITY OF UTILIZING LOWER GRADE FUELS FOR STEAMING PURPOSES

BECAUSE OF the prevailing high price of coal and other fuels much has been done recently in the way of studying our coals with the idea of making a closer analysis of their properties and of finding ways in which more economical combustion can be secured. Special emphasis has been laid on the subject of lignite fuels which have heretofore been, to a large extent, unavailable for use in the ordinary furnace.

Not only is it recognized that our supply of high grade anthracite is limited, but cognizance is also taken of the fact that, in many localities, the average quality of the fuel now being purchased is not as good as that bought under the same name a number of years ago. The difference is due primarily to the increasing amount of incombustible material that is permitted to pass into a coal shipment. The natural result of this higher ash content and consequent lower heating value, in conjunction with the high price, is that the lower grade fuels automatically become relatively more valuable.

CARBONIZING LIGNITE

THIS CONDITION has encouraged experimenting on lignite fuels and an attempt to utilize them on a large scale. In a Report of Investigation on Lignite Carbonization by W. W. Odell, fuel engineer, Bureau of Mines, issued by that bureau, a resume is given of the work conducted by E. J. Babcock, Dean of Mining Engineering, University of North Dakota. The studies conducted under his guidance included briquetting the raw lignite, briquetting the dried and partially carbonized lignite, drying and carbonizing lignite in rotary dryers, horizontal retorts, bee-hive ovens, kilns and inclined ovens.

If briquettes are made simply from dried lignite, complications are met with in handling the material, such as the strong tendency for the dried lignite to ignite spontaneously. Also, the dried lignite does not lend itself well to briquetting.

The conclusion reached in these studies was that the best manner of producing highly desirable fuel from lignite is to briquette a carbonized residue. The aim in general is to produce a fuel for domestic use which, on combustion, will liberate the greatest amount of heat per unit weight of fuel, compatible with an economic method for its manufacture. It is appreciated that a fuel approaching anthracite may be desired for some purposes, whereas briquettes capable of giving a longer flame on burning are desired for other uses. The problem is divided into two phases; the carbonization of lignite, so as to make a suitable material for briquetting; and the briquetting of the carbonized residue with the minimum amount of a suitable binder to form a firm, resistant and even-burning fuel.

During the past summer experiments were conducted for the purposes of ascertaining what results might be expected commercially from a particular type of oven; what methods of control should be used; what yield of gas, tar and ammonia might be realized, and to learn more about the design of a carbonizer best suited for lignite.

The carbonizer used during the tests consisted of 12 inclined retorts. The upper ends are open and a pile, several feet high, of raw lignite, is maintained above them. The carbonized product is drawn off periodically from the lower ends, after being partly cooled by contact with the air ducts or recuperators at the bottom of the setting. Exhaust steam is used to complete the cooling, and is supplied so as to be in contact with the residue at the time it is discharged into the conveyor beneath.

The gas liberated is taken off into a main from which an exhauster draws it and forces it through a cooling system, where the tarry vapors are removed.

and on to a manifold supplying gas to heat the retorts. The gas is supplied to the lower flues and preheated air is used for its combustion. Satisfactory briquettes were obtained which, while not entirely smokeless, held up well in the fire, burned evenly and without severe tests.

Coal Coked in Cars

A new method of coking coal as required for industrial fuel is described by D. S. Chamberlin in a paper read at the Seventh National Exposition of Chemical Industries. The method known as the Whitaker-Pritchard process is one that has given results of special merit.

Run-of-mine coal, 33 per cent volatile, was loaded into cars having a capacity of about 1.5 net tons each, which were run into a horizontal retort. The firing of the tunnel is done at the entrance and the products of combustion are conducted by proper baffles, to all parts of the retort exterior. The flue gases are finally vented from the top.

The products from the distillation are carried from the top of the retort through three offtakes, next through the usual scrubbers and condensers and finally are sucked into a blower. These partially condensed gases and vapors are then delivered under pressure, after proper preheating, back into the retort through two bottom intakes. The excess gas beyond the amount that is constantly being circulated is delivered to a gas holder.

The charge is left in the retort until the gases coming off are reduced to a minimum and are so lean they will not burn. The cars are then taken from the retort into a cooler the same size as the retort, or the coke is quenched at once, depending on whether or not it is desired to conserve the heat.

By this method distillation is carried on at a temperature less than 1300 deg. F.; by the circulation of gases the heat is uniformly controlled throughout the coking mass; a large yield of high B.t.u. gas, amounting to 14,000 cu. ft. per net ton of coal charged, is obtained; a maximum of tars and oils is recovered, due to the scouring action of the returning partially condensed gases; and the cost of operation per ton coal charged is found to be low, as the usual expensive methods of grinding, handling and pushing are eliminated.

Sulphur and Ash Content Reduced by Washing

The object of investigations of bituminous coal washing practice in the Middle Western States, being conducted by the United States Bureau of Mines, the mining department of the University of Illinois, and the Illinois Geological Survey, in co-operation, is to conserve coal resources by minimizing coal losses and to increase the utilization of Middle Western coals for coking and other purposes by reducing the sulphur and ash content. A number of coals have been examined in the field and at the laboratory in order to determine the practicability of washing them. Coals from Clay County, Ind., and from Columbiana County, Ohio, have been washed successfully. Particular attention has been paid to the cleaning of coal on concentrating tables, and to a determination of the factors that affect the washability of coal.

As about one-fourth of the bituminous coal produced in the United States is used in industrial power plants, the waste of unburned coal and coke in the ashes from boiler plants has been investigated. It is possible to recover the greater part of the unburned fuel at a profit by washing the ashes on a concentrating table.

The investigation of the occurrence and distribution of the forms of sulphur in coal is being continued. This work is considered essential because of the depletion of reserves of low-sulphur coal, and it is being conducted with the object of rendering coals high in sulphur more suitable for metallurgical uses. Sulphur reductions obtainable by cleaning a coal depend entirely on the physical and chemical forms of the sulphur in the coal. Sulphur occurring in organic combination with the coal substance and finely disseminated pyritic sulphur can not be removed by washing. Methods have been developed for determining the fine pyritic sulphur, and are described in a bulletin of the University of Illinois, The Distribution of the Forms of Sulphur in the Coal Bed, by H. F. Yancy and Thomas Fraser. Organic sulphur constitutes a larger proportion of the total sulphur in coal than is generally recognized. Of 110 face samples taken in four beds, in 53 samples the organic sulphur made up more than 50 per cent of the total.

Representative samples of run-of-mine coal from a number of mines were tested by screening, the float-and-sink method, and laboratory washing equipment, to determine the degree of separation of ash impurities from the clean coal by washing, and the degree to which the quality of the coal may be improved. At the same mines samples of all washery products were tested by the float-and-sink method to determine the effectiveness of the washers and the possible improvement of their effectiveness by the float-and-sink method of control.

Many supplementary laboratory tests were made with an experimental jig and coal-washing table to determine the possibility of improving the quality of the washed coal and decreasing the loss of good coal in the washery refuse, by the use of improved coal-washing methods and equipment.

The principal results of the tests show that the raw coal, as it comes to the surface, contains much bone, shale and clay, most of which must be removed before the coal is marketable; that the present washeries are inefficient, the washed coal containing avoidable impurities, and the refuse containing an excessive proportion of good coal; that proper adjustment of the washers not only improved the quality of the washed coal but also greatly reduced the loss of good coal in the refuse; that by rearranging present flow sheets and replacing many old machines now in use with improved coal-washing equipment, the practice at each plant could be greatly improved.

Tests of the froth-flotation process, now widely used in concentrating various ores, showed that clean coal can be separated from ash in material passing a 20-mesh sieve or finer. A great many coals, however, contain bone, or bony coal, in which the carbonaceous matter is so intimately mixed with ash that 200-mesh grinding does not separate them. As the bony coal is not as easily floated as the clean coal, retaining the

froth concentrate of coal yields clean coal, the bone forming a "middling." By the use of this method 95 to 98 per cent of the carbonaceous matter in the coal can be recovered in the concentrate and middling and from 30 to 70 per cent of the ash discarded as tailing.

Low Grade Coals Made Available by Pulverizing

Low grade coals containing high percentages of ash can be successfully burned under boilers and even in metallurgical processes by the use of a pulverized coal burner. In a paper "The Use of Powdered Fuel Under Steam Boilers" by H. D. Savage, which was recently presented at a meeting of the American Iron and Steel Institute, a number of installations are described and results of various tests are given to show what results may be expected.

Results of tests on a boiler burning powdered coal at the Oneida Street station of the Milwaukee Electric Railway & Power Co., show that coal containing nearly 14 per cent ash and 3 per cent sulphur was burned with an overall thermal efficiency of 83 per cent. The combustible in the refuse was found to be only 0.36 per cent of the coal fired.

Coals containing much higher percentages of ash can be burned successfully in this way and coals that have heretofore not been available for steaming purposes or have at best been used with low efficiency can be burned with much greater efficiency as the result of pulverizing.

Compounding the Combustion Engine*

Burning Oil Explosively to Get High Pressures, Supercharging to Give Two-Stage Compression, Two High-Pressure Cylinders to One Low-Pressure Giving Simplicity and Light Weight. By Elmer A. Sperry.

ADVANTAGES of compounding for combustion engines have long been recognized, but the mechanical difficulties encountered have led even eminent engineers to conclude that successful working out of a compound combustion engine was impossible. For 30 yr. the author has been experimenting, and in 1890 had a compound engine running, from which much valuable data was secured.

Advantages which have been prophesied and are now on the way to be realized are great decrease in weight, gain in simplicity, increase in thermal, mechanical and overall efficiencies, reduced first cost and lower

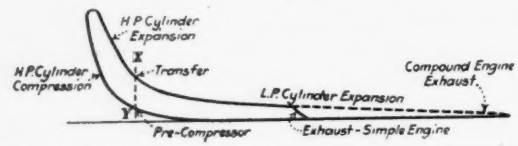


FIG. 1. INDICATOR DIAGRAM SHOWING DIESEL ENGINE, SIMPLE AND COMPOUND

operating cost. There will also be possible engines of larger power per unit, a 10,000-hp. engine being possible within present limitations of cylinder size and wall thickness. As an illustration of weight, a compound engine is now ordered which is to weigh about 5 lb. per brake horsepower, which brings it nearly into the field of aviation engines, while a double engine unit of 3 lb. per hp. is possible.

Using a single cylinder for the entire expansion in a high-pressure combustion engine necessitates a large cylinder in which high pressure must be handled and which must be heavy. It also limits the clearance space in which air is compressed to a small volume so that the combustible charge is cut to a minute quantity as compared to the size of the whole engine.

Taking the Diesel diagram, Fig. 1, and drawing line XY, it is easily seen that for expansion the high pressures and small volume to the left should be handled in a small high-pressure cylinder, while the part to the right and also the extended volume covered by the dotted line should be cared for in a low-pressure cylinder. Also the compression can be best handled in two stages, the part to the left of XY being retained in the high-pressure cylinder. These are the results achieved in the compound combustion engine.

Compound Cycle

By supercharging—compressing in two stages—clearance spaces may be much larger than in the single cylinder engine, permitting a larger charge of fuel, reducing the chilling during compression due to large wall area per unit of volume, and reducing the necessary weight of reciprocating parts, because of the less piston area on which the high pressures act. Also the oil spray can penetrate a considerable volume of hot

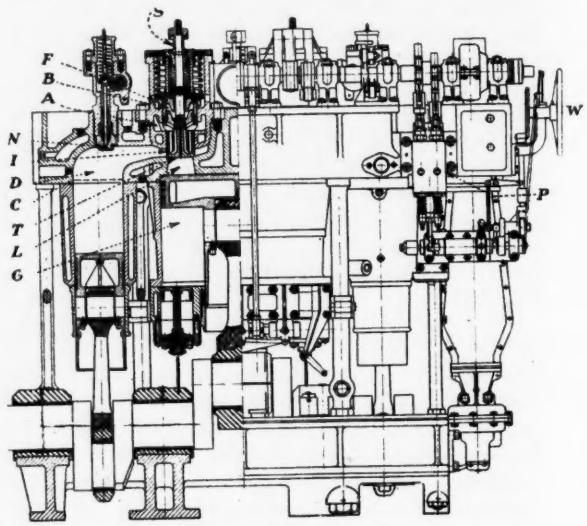


FIG. 2. COMPOUND OIL ENGINE IN HALF SECTION AND HALF ELEVATION

compressed air, without striking the cooler walls of the clearance space; each particle of oil will be surrounded by an air envelope, so that complete rapid combustion results.

Expansion in the small high-pressure cylinder leaves the gases with sufficient pressure so that they can ex-

*Abstracted from a paper presented before the American Society of Mechanical Engineers.

pand 6, 8, even 10 times in the low pressure cylinder with pressure still above atmospheric; so that the total expansion ratio in the engine may be as high as 120.

The large volume of the combustion space permits extending it out toward the low-pressure cylinder as seen at D, Fig. 2, and makes possible a short, direct transfer post, L. The annular space G below the low-pressure piston is utilized for the first compression stage, from atmospheric to about 113 lb.

Another effect sought by the author is 'detonation' in combustion, a rapid burning which raises the pressure at the beginning of the power stroke, giving added diagram area as indicated in Fig. 3, where I shows the effect of first stage compression along line A A B, second stage on line B B C, slow burning C C′, high pressure expansion C′ C″ E, and low pressure expansion E D D. In II the detonation effect is shown at CC′ with addition of the upper toe to the power card,

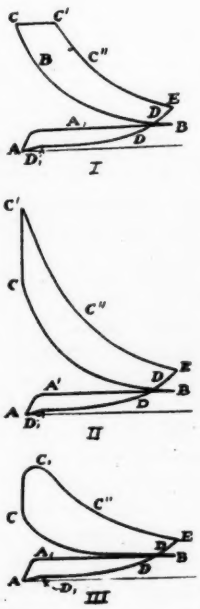


FIG. 3. VARIOUS FORMS OF COMPOUND DIAGRAMS: I, CONSTANT COMBUSTION; II, DETONATING COMBUSTION; III, EFFECT OF DELAYED DETONATION

and higher pressures throughout the high-pressure expansion. Experiment has shown that though detonation has a "distressing" effect in oil engines, its elimination was accomplished by increase in fuel consumption; so that the harnessing of detonation gives better economy as well as removing the limit set on piston speed when constant pressure combustion is sought. It is found that with the solid injection spray nozzle used the effect may be varied at will from that of II to that of III. While peak pressures may seem high, they are not as high as often met in gasoline engines, and ample factor of safety is provided to take care of them.

Valves

Loss during transfer of gas from filling the low-pressure cylinder clearance is eliminated by closing the low-pressure exhaust valve at such point as to compress the trapped gases to transfer pressure, thus equalizing pressures in the cylinders at the time the transfer valve opens.

The transfer flow of gases thus starts slowly as the pistons begin their stroke. Before the flow becomes rapid the transfer valve T, Fig. 2, is withdrawn so that gases pass only across its face. Further, the valve to admit air to the high-pressure cylinder is superposed at I on top of the transfer valve so that the incoming air cools the transfer valve, the cooling action being augmented by serrated surfaces on the back of the transfer valve and by connection currents while both valves are closed. This heating of incoming air also tends to raise its pressure and thus add to the supercharger effect, while the cooling is sufficient to keep the temperature of the transfer valve lower than that of the valves in Liberty motors or simple Diesel engines, so that no other cooling is necessary, although water or mercury cooling could be used.

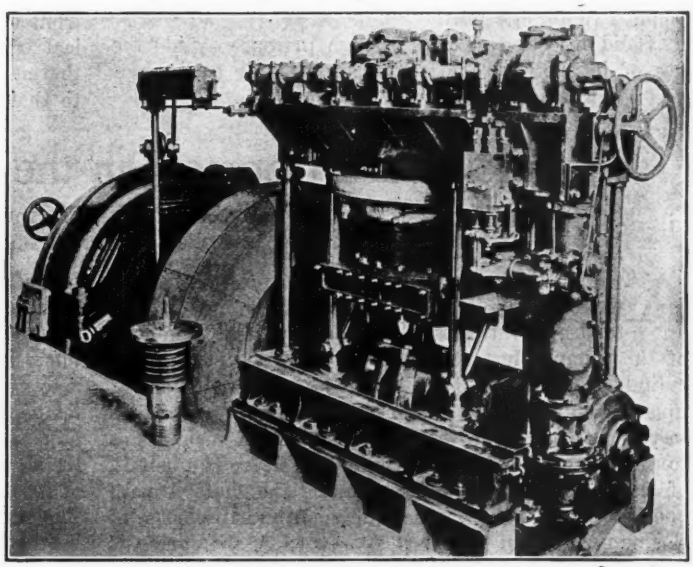


FIG. 4. 7 BY 11 IN. MARINE-TYPE, HEAVY-DUTY COMPOUND OIL ENGINE AND GENERATOR

Valve seats are water-cooled, and the whole valve gear operates continuously and successfully, in perfect condition after thousands of hours of operation. The valves need no attention and are seldom ground in.

Light Weight

As to the reason for the smallness and lightness of the compound engine, the high pressures persist, that is, continue long after ignition, due to the large air and fuel charges possible because of great clearance space. In this way, while initial pressures are not higher than in the simple engine, mean effective pressures are greatly increased, also the expansion is carried further, thus saving the power represented to the dotted toe in Fig. 1. Instead of 60 to 70 lb. net m.e.p. to the crank, delivering power through one stroke in four, there are two power strokes in four, with 300 to 400 lb. m.e.p. each (referred to the high-pressure piston), thus giving better crank effort and distribution. Since the combined net m.e.p. referred to the

high-pressure piston, is, say, ten times that for a simple engine, and power is delivered more steadily, hence more effectively, to the shaft, it is reasonable that the weight of the compound engine may be one-tenth that of a simple engine of like power and speed.

Arrangement and Details

Cylinder volume ratios of 10:1, 8:1 and 6:1 have been tried but the weight factor does not change materially. It is found that power distribution and weight of reciprocating parts equalize best with a ratio 6:1, using two high-pressure cylinders exhausting alternately to one low-pressure between them and three cranks as shown in Fig. 2. The high-pressure cylinders thus work on a four-stroke cycle, and the low-pressure on a two-stroke cycle, so that the same impulse sequence is obtained as for four simple cylinders. Complete reversibility and self air starting on compressed air from the supercharger are secured without additional valves or cams, only five cams driving seven valves being used for the unit.

Solid injection of fuel at high pressure avoids the use of high-pressure injection air and air compressor and saves the power for the compressor.

Oil pumps feed constantly into a constant-pressure trunk line with accumulator and adjustable relief valves, admission of fuel being controlled by adjusting the timing and lift of the fuel valves while running pistons, accumulator plunger and valve stems are ground in and need no packing.

Fuel pumps are shown at P, Fig. 2, and the wheel for controlling timing and life of fuel valves N at W. Air induction valve I is lifted by the cam-operated fork F, and transfer valve T with its sleeve by a fork, not shown, operating in spool S. The annular compression pump delivers air to a small receiver located above the crank case, whence the air is led to cored port A. The little balancing cylinder B sustains a permanent connection with the low-pressure cylinder.

Figure 4 is a marine type compound engine with high-pressure cylinder 7 by 11 in. and cylinder volume ratio of 10:1 running at 400 r.p.m. and piston speed of 700 ft. per min. It would be rated at about 180 hp. One of the transfer valves is shown on the floor in front of the engine. On motor-driven test the mechanical efficiency is found to be about 93 per cent and thermal efficiency ratio of power delivered to the shaft to that in the fuel is estimated at 40 to 50 per cent.

Foreign Development in the Power Plant Field

A New Valveless Pump, a Flexible Friction Clutch and a "Turbine" Firebox Mark European Progress in Engineering. By J. H. Blakey

At the Mechanical and Marine Exposition held at the Olympia Palace in London, England, in September, a valveless pump was exhibited. The body of the pump, illustrated in Fig. 1, is of the ordinary cylindrical form. It is traversed by a central shaft A, upon which is screwed a spring in the form of a C, which in turn is enclosed in the brass sleeve D, of such size as to produce easy friction. Around this sleeve is a belt E, of leather or rubber, which connects the shaft A with another placed between the admission and discharge of the pump. When the shaft A is turned, the spring C acts as an eccentric, displacing the sleeve in such a way that the belt moves from one side to the other of the cylindrical chamber. Thus the liquid may be driven in either direction according to the direction of rotation of the shaft A. The elasticity of the motor spring C together with that of the belt, enables the pump to handle liquids containing a large amount of solid matter. It is to be noticed that the belt does not turn, so that its only wear is due to the friction in the body of the pump.

The pump is made in models having the admission from ⅜ in. up to 4 in. in diameter. The ¾-in. pump exhibited at the Olympia, when running at 900 r.p.m., raises about 250 gal. of water to a height of 50 ft. It weighs about 50 lb., including its motor and coupling.

Fall of Temperature in Superheated Steam Pipes

Mons. Chas. Pasquay writes on this subject in Le Genie Civil of October 29. A prospective customer frequently asks of a manufacturer of heat insulators the question: What maximum fall of temperature per running foot of pipe do you guarantee with your insulation? without thinking that this question cannot be answered without qualification. Numerous tests have shown that for the same pipe protected by the same insulation, the fall of temperature varies from day to day, according to its discharge. In fact, the fall of temperature in a superheated steam pipe depends upon the relation of the weight of steam which it carries to its surface; that is to say, to the diameter of the pipe, and to the pressure, temperature and speed of the steam. It is the same case as a water pipe in the open air; the smaller it is and the slower the movement of the water, the more danger of freezing in winter; while a large pipe runs less risk. The surface of the pipe, which emits the heat, increases in direct relation to the diameter, while its content increases according to the square of the diameter.

If we know the number of calories, m, given off by one running foot of a pipe in a given time, the fall of temperature, t, is given by the formula: $t = m \div a \times c$ where a represents the weight of steam which the pipe carries in the given time, and c the specific heat of the steam.

Taking 250 deg. C. as the temperature of the superheated steam, for different pipe diameters, pressures and speeds, according to the formulas of Peclet, given in his Traite de la Chaleur, the following results have been found for an insulator reducing the heat loss by 90 per cent:

Flow of steam in ft.-secs.	—15—		—30—		—60—		—120—	
Absolute pressure in lbs.	85	142	85	142	85	142	85	142
Inside pipe dia.	Loss of heat in degrees Centigrade							
1 in.	.27	.16	.13	.08	.07	.04	.03	.02
3¾ in.	.94	.55	.46	.27	.23	.14	.12	.07
2 in.	2.12	1.26	1.06	.63	.53	.31	.26	.16

These figures are not absolute, but they agree sufficiently well with actual tests made under favorable conditions. This table shows the great influence of the speed of the steam upon the fall of temperature, an influence which is not always sufficiently recognized by

the designer and plant owner. Quite often, under pretext of avoiding losses of pressure by friction, a too large diameter is chosen for the pipes, so that the speed of the steam is only from 20 to 40 ft. per sec. Now it has been proven that in well installed piping, avoiding as much as possible sharp turns and other causes of obstruction, superheated steam even at speeds of 160 to 240 ft. per sec. decreases very little in pressure. If we remember that a fall of pressure of 3 or 4 lb. represents only a very small number of calories lost in comparison with the loss resulting from an unnecessarily large surface of pipe, it will be seen that there is every advantage—especially in the case of a piping system of considerable length—to allow for a fall of pressure of a few pounds and to reduce the pipe diameter so as to obtain a speed of from 120 to 160 ft. per sec. This will result in a triple advantage: reduction of the loss of heat, of the cost of piping, and of the price of the pipe covering.

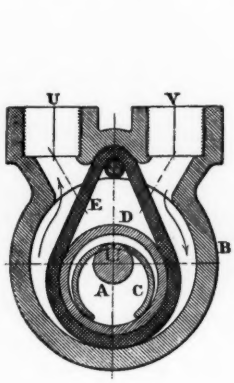


FIG. 1

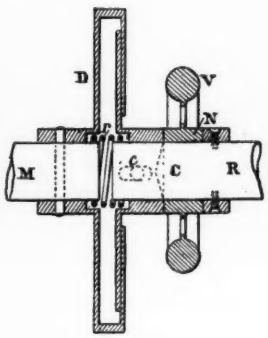


FIG. 2

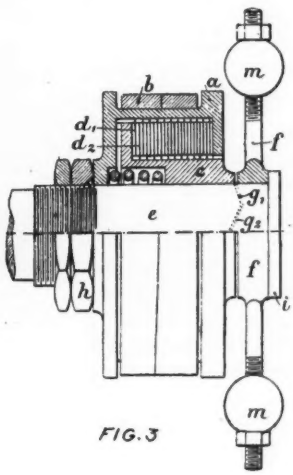


FIG. 3

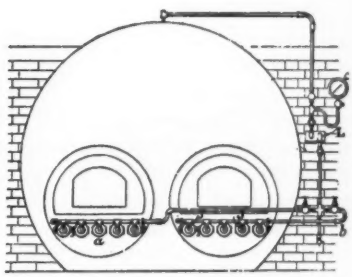


FIG. 7

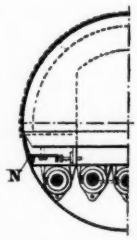


FIG. 4

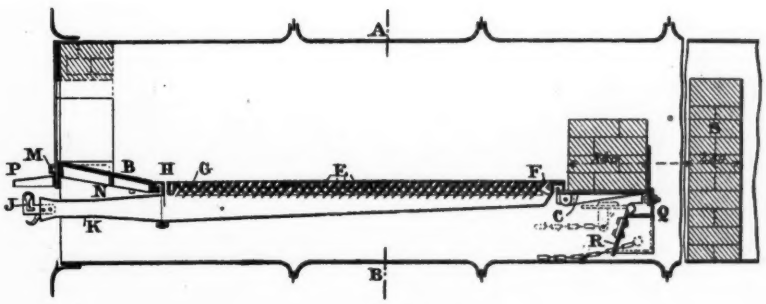


FIG. 5

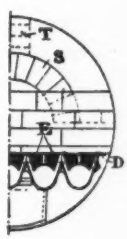


FIG. 6

FIG. 1. SECTION THROUGH VALVELESS PUMP. FIG. 2. DIAGRAM SHOWING PRINCIPLE OF TRANSMISSION IN REMONDY CLUTCH. FIG. 3. APPLICATION OF REMONDY PRINCIPLE TO A BRAKE. FIG. 4. END VIEW OF FURNACE. FIG. 5. LONGITUDINAL VIEW OF "TURBINE" FIREBOX. FIG. 6. HALF SECTIONAL VIEW ON A-B. FIG. 7. STEAM CONNECTIONS

The Remondy Flexible Friction Clutch

This clutch has been called by its inventor an "automatically progressive transmission." The value of a clutch which is perfectly flexible and which will deaden the shock produced by sudden starting or stopping, or the putting into action of a heavy machine from a line shaft, needs no argument. Figure 2 shows the Remondy clutch. The motor shaft M carries, pinned or keyed on the end, the friction disk D. The driven shaft R is furnished with a corresponding disc upon a sleeve. This sleeve is not keyed to the shaft but is driven by a stud or feather c, which moves in a groove on the inner surface of the sleeve, thus allowing this a longitudinal movement on the shaft. A spring r tends to push back the sleeve on its shaft and so holds the discs together. Behind the sleeve is a wheel V, mounted with easy friction on the shaft, but not fastened. Its boss rests against the end of the sleeve, in which are cut two inclined surfaces corresponding to similar surfaces on the wheel boss, one of which is shown at C. The working of the apparatus is as follows: When the motor force and the resistance remain constant the whole appliance works together as an ordinary disc coupling; the power of the motor is transmitted to the machine by the pressing together of the discs without friction, as the result of the action of the spring r. The two shafts then rotate as one, the transmission operating without changing the speed. But if the resistance increases suddenly the speed of the resisting shaft tends to diminish, and the wheel V on account of its inertia keeps its acquired speed; it tends then to rotate with regard to the shaft R, on which it is not fastened. This rotation has the effect of causing the inclined surfaces C to act upon each other, so driving the disc sleeve backward against the action of the spring r. Thus the discs are separated, or at least bear with diminished pressure upon each other, and the sudden

increase of resistance is not transmitted to the motor, which can continue turning at its normal speed. But as soon as the action of the wheel on the end of the sleeve becomes less than the opposing action of the spring at its other end, the perfect contact of the discs is renewed and the two shafts run together again as one. It will be seen that a sudden increase of speed on the part of the motor will be gradually transmitted by the rotation of the wheel in the reverse direction, and that this may be as effective in preventing damage as the other movement. In Fig. 2 the contact pieces shown are discs, but of course two cones will serve equally well.

The same principle can be applied to a brake. Figure 3 shows such an arrangement. The sleeve c is mounted on the shaft in the same way as is Fig. 2, and is in contact with the brake drum by means of the friction discs d. The wheel V in Fig. 1 is here replaced by two arms f, carrying the weights m, the position of which on the arms can be changed to suit varying conditions.

The "Turbine" Firebox for Steam Boilers

The high price of fuels in Europe has drawn the attention of boiler makers to the construction of grates specially designed for fuels of poor quality, such as coal and coke fragments and dust, and in fact anything combustible. Such a firebox is shown in the accompanying figures as used in a Lancashire boiler. The grate is composed of a number of gutters or conduits (in this case five) serving as support for the transverse elements. These elements present a certain analogy to the vanes of a turbine: whence the name. The gutters have at the front a radius of about 2 in., and a breadth at the top of about 6 in. They are prolonged into the front of the firebox by a narrowed cylindrical part K (Figs. 4 to 6), into which steam is blown by the injector J, which has an orifice measuring 0.06 in. in diameter. Steam is taken from the boiler as shown in Fig. 7, being first superheated and then passed through the reducing valve L. The grate bars, which are supported by the upper edges of the gutter, have an addition at each side, as shown at E, one of these being inclined at 45 deg. and the other at 60 deg. to the surface of the bar. The open space between two adjoining projections is about ⅛ in.

This arrangement has been found to give a very even distribution of air to the fire, and the consumption of steam is so small as to be negligible. Tests made in England and in Belgium have given very satisfactory results, the production of steam being increased from 40 to 60 per cent. These figures are apt to be misleading unless it is remembered that the fuels used were of such poor quality that with an ordinary grate the steam production would have been very small indeed.

Paint for New and Old Concrete Floors

The following is an excellent paint for the treatment of old and new concrete floors and has been used by several western sugar refineries with very satisfactory results. The resulting finish appears to be resistant to almost everything, including oil: One part Portland cement (weight), one part kerosene. Thoroughly mix by sifting the cement into the kerosene very slowly and stirring vigorously. After thorough mixing has been secured, mix with four parts real coal tar. The latter must be real coal tar—not oil tar. Apply cold as ordinary paint. C. C. Brown.

New Type Steam Driven Air Compressor

OF LATE years, the builders of steam driven air compressors have made little effort to improve the steam economy of their machines. The development of steam driven air compressors has not kept pace with the development of the steam engine and today the steam consumption per unit of work of the former is much higher than that of the most modern steam

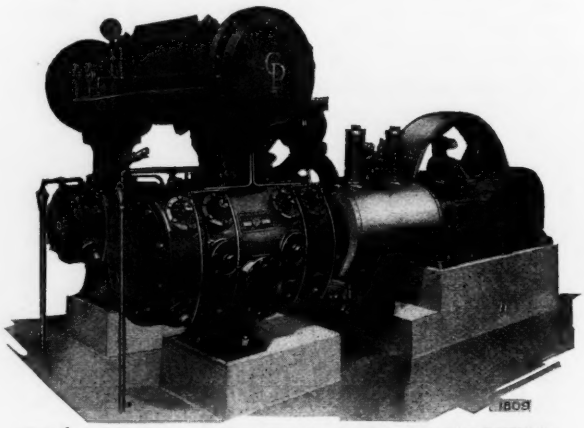


FIG. 1. THE DUAL FLOW STEAM DRIVEN AIR COMPRESSOR

engines built for general service. The need for improvement in compressor design has been increased considerably in recent years by the widespread and ever growing use of superheated, high pressure steam.

A new machine has been recently developed by the Chicago Pneumatic Tool Co., however, which is extremely economical in the consumption of steam and meets the

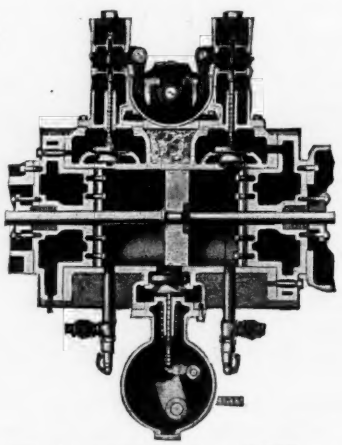


FIG. 2. SECTION OF CYLINDER

conditions imposed by high pressure superheated steam with considerable success. It is known as the Dual Flow steam driven air compressor and although entirely new, is not an experimental innovation. The design is based upon principles which have already proven their soundness and superiority in steam engine practice. The machine is illustrated in Fig. 1.

A particular feature of the new machine is the steam cylinder which is so constructed as to eliminate initial

condensation to a minimum. Initial condensation, as is well known, represents a considerable loss of power and is caused by the cooling of the cylinder walls and head by the comparatively cool exhaust steam as it washes over them in leaving the cylinder.

In the machine under consideration the exhaust steam does not wash back over the cylinder walls and head, but leaves through a port in the center of the cylinder and the interior surfaces of the cylinder walls and head remain at very nearly the same temperature as the entering steam. The exhaust port is uncovered by the piston when the latter has traveled about half its stroke. The exhaust is controlled, however, by a steam-

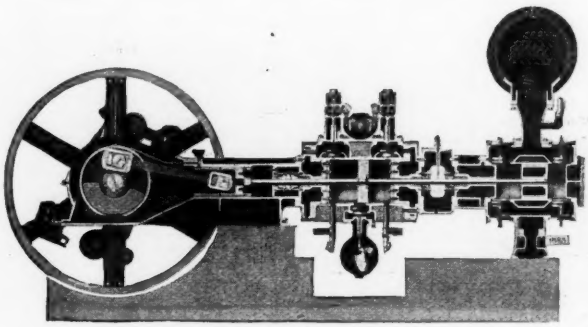


FIG. 3. LONGITUDINAL SECTION OF MACHINE

tight poppet valve, which opens when the piston is near the end of its stroke and closes again (if the machine is running noncondensing) when the piston covers the port on the return stroke. When running condensing, the valve, of course, closes very early in the return stroke. Compression does not begin until the piston has traveled half the return stroke.

A shorter cylinder and piston is made possible in this type of engine than is obtainable with the usual unaflow engine and as a consequence the weight of the reciprocating parts is decreased. Friction is also reduced and the cylinder is easily lubricated.

Valve leakage in steam engines is another cause of steam loss which is difficult to eliminate, especially where high pressure, superheated steam is used. In the Dual Flow, the adoption of the Skinner, double-seat poppet valve for both admission and exhaust reduces valve leakage to a minimum. This valve will remain steam-tight indefinitely and will seat perfectly, regardless of the pressure or temperature under which the cylinder is operated. It has been known to keep steam-tight, with one grinding, with 159 lb. pressure and 150 deg. F. superheat and also with saturated steam at 100 lb. pressure. No lubrication is required.

Inequalities of expansion of the metals forming the valve and seat due to different co-efficients of expansion are compensated for and there is no side thrust imposed upon the stem by the lifting mechanism.

The governor is mounted in the flywheel and operated by centrifugal force and inertia. The governor arm is connected to the steam valve eccentric, and by changing the throw of the latter, it changes the point of the cutoff of the steam entering the cylinder. Variations in speed may be made by adding or removing weights.

The Dual Flow is a constant speed machine, and shows the best steam economy when operating at its greatest speed. Regulation is effected by two-step capacity control; two differential unloaders connect with the inlet valves, and reduce the capacity of the compressor in two steps. One unloader holds open the inlet valves on the crank end of one cylinder and the head end of the other; the second unloader holds open the inlet valves at the opposite ends.

The air valves are of the well-known Simplate independent disc type.

Boiler Plant Efficiency

ABSTRACT OF PAPER DELIVERED BEFORE THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS TO SHOW TO WHAT EXTENT BOILER ROOM WASTES ARE PREVENTABLE. BY VICTOR J. AZBE

THE DEGREE of waste in boiler plants is not generally realized and there is a tendency to judge conditions by a few of the better plants where improvements have been made and whose results are considered as representative of the average-run boiler plants. This is unfortunate and the author ventures the statement that while considerable improvement resulted from the efforts of the U. S. Fuel Administration, the field of opportunity was barely scratched.

The writer considers 90 per cent efficiency as the standard of economy attainable under favorable conditions, this 90 per cent representing boiler and economizer without taking auxiliary power into consideration, however. The requirements for this efficiency are rather severe and with 12,000 B.t.u. bituminous coal, 15 per cent excess air would have to be used, flue gas temperatures would have to be no more than 250 deg. F., combustion complete and no carbon in the ash. The ideal or 90 per cent efficiency was attained only once, by Henry Kreisinger and John Blizard at the Lakeside Station of the Milwaukee Electric Railway & Light Co.

FUELS

WITH A SUITABLE installation, almost as high an efficiency will be obtained with low as with high-grade fuels. The only real obstacle to this is the tendency toward a greater ashpit loss with lower-grade fuels. As far as any other factors are concerned, if we analyze them we note that with proper installation their effect is very small. One reason for poor boiler-room efficiency and lack of entire success with low-grade fuels is the tendency of one man to copy equipment without sufficiently considering the necessary adjustments for adaptation to the different conditions.

As a rule low-grade fuel should be burned close to the mines and higher-grade fuel transported. The mines should be especially equipped to burn the very lowest-grade fuels, such as the fine material scooped from under the coal seam by the coal-cutting machine.

Freight to distant points should not be compared on a tonnage but rather on a heat-value basis. The cost of fuel also should be based on heat value rather than on weight.

As to fuel oil, it should be made an offense against the law to burn crude oil under boiler furnaces; only the use of residue from oil refineries should be permissible and that should be conserved as much as possible for ocean-going steamers and locomotives.

Combustion

There are several reasons why properly proportioned furnaces with ample combustion space are necessary, the most important being the prevention of escape of unburned gas and formation of soot, the possibility of operating with the least amount of excess air without incomplete combustion and the prevention of flame entrance among the boiler flues.

mixing with air, takes place on a grate. With Illinois coal and a combustion chamber of 0.5 cu. ft. per lb. of coal burned, very good results should be obtained provided the arrangement is correct. Figure 1 shows test results made by the U. S. Navy Department. The large combustion space is primarily the reason why an efficiency of 66.5 per cent is possible with a rating of 400 per cent. With an ordinary installation and such high rating, flame would be noticeable in the uptake, flue-gas temperature would exceed 1000 deg. F. and boiler efficiency be decidedly less than 50 per cent.

The aim is to have the gas completely burned and no flame entering the first tube pass. To accomplish this, more than mere furnace volume is necessary.

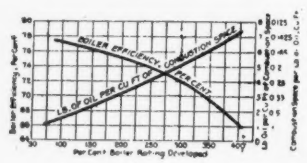
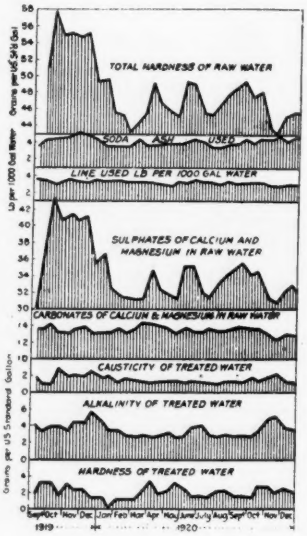
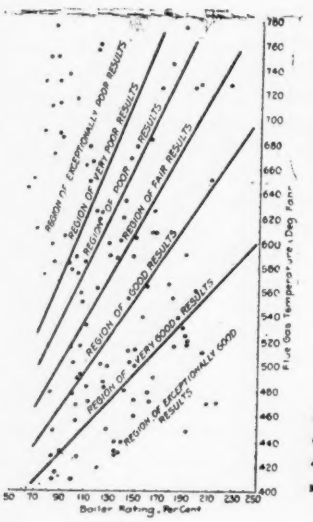


FIG 1


TOTAL HARDNESS OF RAW WATER
LIME USED LB PER 1000 GAL WATER
SULPHATES OF CALCIUM AND MAGNESIUM IN RAW WATER
CARBONATES OF CALCIUM & MAGNESIUM IN RAW WATER
CAUSTICITY OF TREATED WATER
ALKALINITY OF TREATED WATER
HARDNESS OF TREATED WATER
1919
1920
FIG 3


REGION OF EXCEPTIONALLY POOR RESULTS
REGION OF VERY POOR RESULTS
REGION OF POOR RESULTS
REGION OF FAIR RESULTS
REGION OF GOOD RESULTS
REGION OF VERY GOOD RESULTS
REGION OF EXCEPTIONALLY GOOD RESULTS
Flue Gas Temperature, Deg Fahr.
Boiler Rating, Per Cent
FIG 2

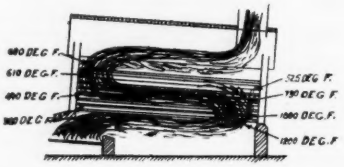


FIG 4

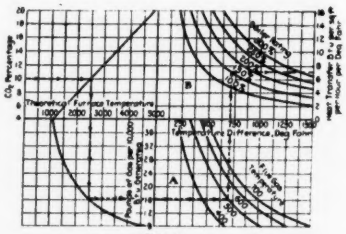
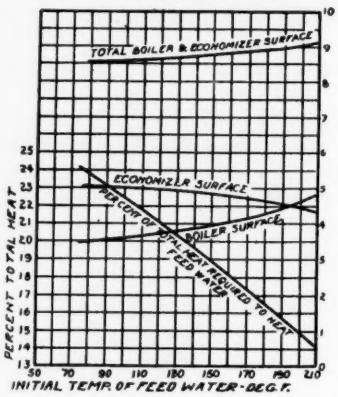


FIG 5


TOTAL BOILER & ECONOMIZER SURFACE
ECONOMIZER SURFACE
BOILER SURFACE
PERCENT TOTAL HEAT
HEAT REQUIRED TO HEAT FEED WATER
INITIAL TEMP OF FEED WATER - DEG F.
FIG 6

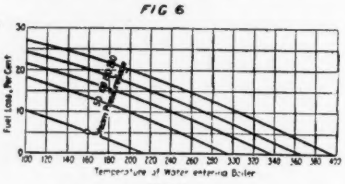


FIG 7

FIG. 1. RESULTS OF IMPROVING BOILER EFFICIENCY AS SHOWN BY TESTS OF U. S. NAVY DEPARTMENT. FIG. 2. FLUE GAS TEMPERATURE REPRESENTATIVE OF GOOD AND BAD RESULTS. FIG. 3. RESULTS OF A BOILER FEED WATER TREATING PLANT, HOT SYSTEM. FIG. 4. UNEQUAL GAS FLOW DISTRIBUTION THROUGH A BOILER.. FIG. 5. BOILER HEAT-TRANSFER VARIATION UNDER DIFFERENT CONDITIONS. FIG. 6. HEAT REQUIRED TO RAISE FEED WATER TO TEMPERATURE OF 350 DEG. F. FIG. 7. FUEL LOSS WHEN WATER ENTERS BOILER BELOW STEAM TEMPERATURE.

Furnace volumes vary from 1 cu. ft. per lb. of coal burned per hour down to less than 0.1 cu. ft. in some cases. The lower amounts, of course, do not represent the entire combustion space because combustion under such conditions extends among the tubes, at times for a considerable distance, but this is not what is to be desired. The larger amounts are used with powdered fuel and are necessary because the solid particles burning are relatively large and require a larger combustion chamber for their gasification and combustion than is the case when gasification and to a certain extent

Owing to the tendency of the gas to take the shortest path, the combustion space should be of relatively small cross-section and great length. The cross-section should be as uniform as possible, and where it changes it should do so gradually, except where mixing effect is intended. The most effective combustion space is right above the fuel bed where the gas has not had the chance to arrange itself in high and low-velocity streams, and therefore ample space at this point is most to be desired.

The combustion space required varies with the composition of fuel burned and the conditions under

which it is burned. It is very apparent that with hand firing larger combustion space will be required than with stokers, from which the volatile matter is given off more uniformly. Excess air is an extremely important factor; temperature also has an important influence, and it is fortunate that as excess air reduces temperature increases.

Excess Air

The largest preventable loss in boiler plants is that caused by excess air, and determination of this loss by the measure of the CO_2 and flue-gas temperature has achieved considerable popularity. However, where such popularity has been attained the trouble has been that quite generally there is satisfaction if the fuel is burned with 100 per cent excess air, and even in well-operated plants no better results are obtained on the average. This is because of the tendency of many an engineer to assume statements as correct without consideration of the circumstances. With the large combustion chambers coming into vogue nowadays, the old assumption that 10 or 12 per cent CO_2 is all that pays becomes obsolete. If we design our furnaces so that flame terminates before gas enters the tubes, or soon thereafter, and we have the boiler heating surface so exposed that the maximum possible amount of heat is radiated to it, then the standard of good performance is the burning of the fuel with 15 or at the very most 25 per cent of excess air, and CO_2 maintained should be around 16 per cent.

The point at which excess air enters is very important and should be given greater prominence when boiler-test data are being recorded. At present during a test we tend to be primarily concerned with what occurs on the ends, that is, in the furnace and uptake, and few, if any, observations are taken and records made of what occurs between these points. Such items as point of flame termination, relative amount of oxygen, carbon-dioxide percentages (which are true measures of excess air), and temperature drop at various points through the settings, should be carefully recorded and interpreted; then it will be possible really to compare the performance of one boiler with another.

A somewhat overlooked but also very important factor affecting boiler-plant economy is "constancy." The percentage of CO_2 may fluctuate during the day from high to low, but if for the whole day a 10 per cent average is taken, it will be found that, for a number of reasons, the efficiency will not be nearly so good as when 10 per cent of CO_2 is constantly maintained. Therefore the average CO_2 when it fluctuates is an improper measure of the loss but at the same time a good indicator of improper conditions.

Heat Transfer and Flue-Gas Temperature

The temperature of the escaping products of combustion determines fuel loss to a great extent, but what is low and what is high flue-gas temperature? The lack of suitable measure and standard has in the past prevented proper comparison of results and has caused a certain lack of incentive for improvement.

The writer, in an effort to evolve a measure, has drawn Fig. 2 based on 150 different boiler tests. Each dot represents the average flue gas temperature at the average rating developed in each test. The space is divided into sections varying from exceptionally good to exceptionally bad results, with the slope of the line following as closely as possible the increase of flue-gas temperature with the increase of boiler output of a number of boiler-test series.

To obtain a low flue-gas temperature, it is necessary that the heating surface be clean. That the heating surface can be kept clean internally is shown by Fig. 3, which gives graphical results of a boiler feed water treating plant over a period of 16 mo. with extremely bad make-up water. It will be noted that the hardness was reduced from an average of 48 to slightly over 2 grains per U. S. gallon. Regarding soot formation on the tubes, a great deal depends upon size of combustion chamber, which if ample will greatly facilitate the keeping of clean surfaces.

To absorb heat it is necessary to bring the gas in contact with the heating surface. This some boilers do imperfectly. If the surface is clean everything depends upon gas velocity and distribution. The gas has the tendency to take the shortest cut, a great deal like a stream of water.

The cross-sectional area of a boiler pass should be such as to permit the highest gas velocity consistent with the draft available, and also such that the velocity will be constant and not reduce as the gas cools off.

Figure 5 was drawn in an effort to show how boiler heat transfer varies according to different influencing factors. This chart is interesting from many angles and while not exactly correct for all conditions, it is sufficiently so to permit its use. It is based on the theory that from the actual heat-transfer standpoint we are not concerned with what the furnace temperature is, but only with the maximum theoretical temperature that would have existed had there been no absorption of heat in the furnace. If the boiler absorbed no heat from the furnace, the theoretical temperature corresponding to CO_2 would be obtained very nearly. According to this theory, if CO_2, flue gas temperature, and rating at which the boiler is operated are known, heat transfer can be determined with the aid of the chart. The heat transfer is both by radiation and connection and the chart is based upon steam temperature of 365 deg. F.

Since heat-transfer ability is the only possible measure of the efficiency of the boiler itself, it should be apparent that the method should have value in helping to segregate boiler and stoker performance and placing boiler performance on a definite basis of measurement.

Figure 6 demonstrates that with 140 lb. boiler pressure, from 14 to 25 per cent of the total heat used to generate steam is required just to heat the feed water to 350 deg. F. It also shows how the necessary boiler and economizer surface varies with different temperatures of feed water and that the total boiler and economizer surface is less than the necessary surface of the boiler without economizer. For maximum economy, counter-current heat-flow effect must be employed in boiler plants.

Economizers pay under almost any conditions if they are installed correctly, especially if we take into consideration that they replace more than their own amount of boiler surface. It should be general practice to install smaller boilers which may be forced to greater overloads and the consequently high flue-gas temperatures reduced in economizers. Water should always enter boilers at

above 325 deg. F. In fact, it is the approach of feed water temperature to steam temperature in the boiler that is a measure of fuel loss resulting from not employing at all or not to a full enough extent the principle of counter-current heat flow. Figure 7 applies when there is sufficient heat in the flue gas to heat the water to the temperature of steam, giving fuel loss for whatever temperature water enters the boiler. With this chart it is possible to tell not only what good a certain economizer installation accomplished but also what good it does not accomplish.

If a boiler would reduce the temperature of flue gas to the temperature of water in the boiler, the boiler heating surface very evidently would be 100 per cent efficient, no matter what the combined boiler surface and stoker efficiency would be. Figure 8 has been drawn

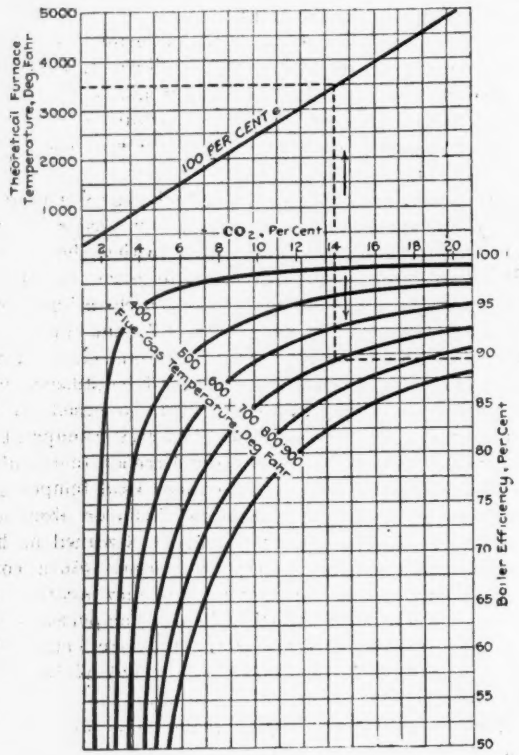


FIG. 8. EFFICIENCY OF A BOILER AS A HEAT ABSORBER

in an effort to show the relation of furnace temperature, CO_2, flue-gas temperature, and boiler efficiency for a boiler temperature of 365 deg. F. This chart has some limitations, but it nevertheless shows that a boiler as a heat absorber can be 99 per cent efficient.

Boiler Capacity

When boiler capacity is increased by the burning of more fuel, the following either do or may occur:

(a) Temperature in combustion chamber increases.

(b) Temperature of gas throughout boiler setting increases.

(c) Temperature difference between water in boiler and gas surrounding tubes and drums increases.

(d) Gas velocity increases.

(e) Heat absorption by radiation increases owing to higher furnace temperature.

(f) Heat absorption by convection increases owing to higher gas velocity and higher temperature difference.

(g) Flue-gas temperature increases.

(h) Dead spaces become more active.

(i) Incomplete combustion increases.

(j) Fuel loss resulting from air in leakage and radiation expressed as a percentage of total decreases.

(k) Excess air decreases.

(l) Fireman's attention usually increases.

(m) Return received from investment increases.

But it is not really the fault of the boiler that efficiency is low at low ratings. The fault lies either with the setting, the stoker, or the fireman, and is usually due to them all.

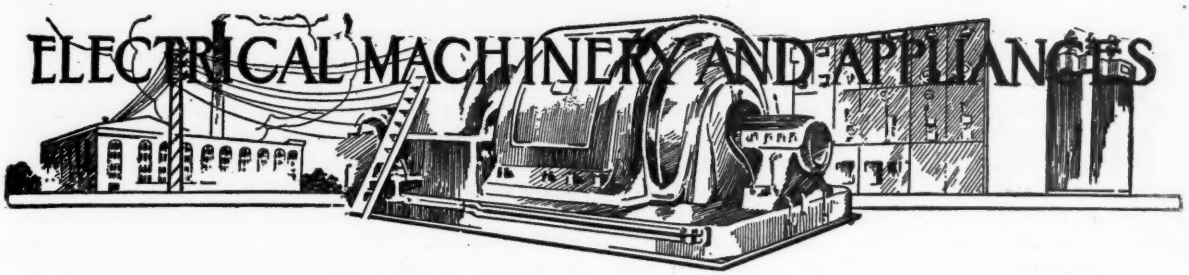
Since high boiler efficiency at low ratings is more difficult to obtain than at high ratings, it follows that owing to this and also for investment reasons, boilers should be installed designed for high overloads and high and constant efficiency over a considerable capacity range. Especially in plants where load varies a great deal the boilers should be able to take the peaks; even if these peak loads are somewhat uneconomical they are to be preferred to boilers loafing the greater part of the time. As a rule good boilers, well installed, should be operated at between 150 and 200 per cent of rating, and when a peak is of short duration 300 per cent of rating is permissible. Ratings below 150 per cent should not be permitted, except under unavoidable circumstances. The proper rating at which to operate a boiler depends upon circumstances. In Fig. 2 one boiler has a flue-gas temperature of over 700 deg. F. at 100 per cent rating, while another has only 510 deg. F. at 200 per cent. Of course the first is entirely unfit for any overload capacity, while the second is good for as much as 300 per cent of rating.

Investment

A new up-to-date installation designed for high capacity and efficiency does not cost initially much more, if any more, per horsepower developed than the ordinary run of wasteful plants. The subsequent operation of such a plant will be cheaper and so the fuel saving is almost entirely a net saving. It is certainly better to pay twice the amount per rated horsepower for an installation having 100 per cent overload capacity at high efficiency and economical in labor, than only half this amount for a wasteful installation capable only of an output around rating.

Nowhere is there such an opportunity for good return on the investment as in the boiler house, where a few dollars properly applied can perform wonders. But there are also properly designed plants that are wasteful, due to human inefficiency, and to such beliefs as that stokers are a failure, high CO_2 harmful, economizers a poor investment, superheated steam impractical, etc. It is the man who designs or operates who is at fault, rather than the equipment. The fireman is more important than the stoker, and since good firemen are scarce, it is preferable to purchase equipment which is as nearly foolproof as possible.

When equipment is already installed but not considered satisfactory, great care should be taken to find out if it is really necessary to make a change before an expenditure is recommended.



Electric Elevator Drive---I

CONSIDERATIONS OF VALUE TO THE MAN SELECTING EQUIPMENT FOR A PARTICULAR KIND OF SERVICE. BY GORDON FOX

ONE OF the pioneer applications of electric motor drive was for elevator service. Due to the varied and exact requirements a high degree of perfection has been attained. The lessons learned in the successful development of elevator drive and control have been applied along other lines and have materially assisted in the improvement of motor and control equipments in general.

As elevators are used for both passenger and freight service and in high and low buildings, the requirements vary widely and equipments differ in corresponding degree. The essential parts, however, are similar in all types. The essential parts are the car, the counterweights, the winding machine, guide sheaves and cable. Elevator cars for both passenger and freight service are familiar to all, both in appearance and method of guiding the car in the shaft. Counterweights may be applied in various ways and systems of counterweighting may be profitably discussed.

The purpose of the counterweight is to reduce the work required of the motor and brake and to minimize the current peaks involved in frequent starting and stopping. Single counterweights are sometimes arranged to counterbalance the car directly through a cable attached to car and counterweight and passing over a head sheave at the top of the shaft. This arrangement is simple, but requires that the counterweight be less than the empty car weight in order that the car will lower by its marginal weight. A more common arrangement is a single counterweight roped to the hoist drum and leading off diametrically opposed to the car ropes. When the car lifts, the car ropes are wound up on the drum and, at the same time, the counterweight ropes unwind, allowing the counterweight to lower. This arrangement, permitting both car and counterweight cables to utilize the same grooving on the drum, takes a short drum. This may be of decided advantage due to space limitations. It also affords good cable alinement. This general method of counterweighting permits the counterweight to be heavier than the empty car. It is customary to counterweight for the car weight plus half the weight of the average load. The marginal weight then corresponds to about 30 to 40 per cent of the maximum load.

A third method of counterweighting is frequently used in which the counterweight is divided into two sections running in the same guides but having separate frames, located one above the other. The upper counterweight is the car counterweight. This is somewhat less than the weight of the car. Cables from this counterweight pass over a head sheave directly to the car. The lower of the two counterweights is connected to the drum, the cables passing through holes in the upper counterweight. It may be seen that this arrangement relieves the pull on the cables attached to the drum so that heavier loads may be handled or less drum cables used. It may be observed at this point that a number of cables are usually placed in multiple, the hoisting ropes being commonly 5/8 in. extra flexible steel cable.

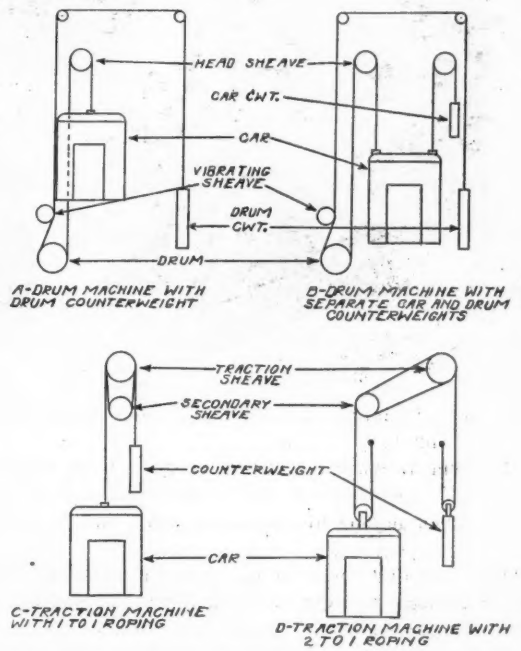


FIG. 1. PREVAILING METHODS OF ELEVATOR ROPING

The arrangement of guide sheaves depends upon the type and location of the hoisting engine and the method and location of counterweights.

TYPES OF WINDING ENGINES

ELEVATOR HOIST engines may be located either at the top or bottom of the shaft. If the machine is located at the top, the supports must carry the car weight, counterweight, weight of ropes to car and counterweights and weight of hoisting engine. If the machine is located at the bottom of the shaft, the supports must carry the

weight of car and counterweight and cables to car, counterweight and drum in addition to the downward pull of the drum cables. For tall buildings, the hoisting engine is commonly located at the top of the shaft. In low buildings the bottom location is more common.

Elevator winding engines are of several types. For a very simple and cheap layout for a small, slow speed freight elevator, belt drive is sometimes used from motor to winding machine. The motor runs continuously at constant speed. Straight and crossed belts are used for reversal of travel. Tight and loose pulleys or clutches may be used. This arrangement is also adapted for group drive from a line shaft. The most common type of elevator machine comprises a winding drum driven through a worm wheel and gear, mounted on a common bed plate with motor and brake. Figure 2 illustrates such a machine. The sheaves shown are termed vibrator sheaves. These travel along their axle shaft and guide the rope to and from the drum. The thrust at the worm shaft is taken by a ball or roller thrust bearing. Some equipments for heavier duty utilize two worms cut right and left and two worm wheels which, in turn, mesh together. With this arrangement end thrust is eliminated. Sometimes, for very slow speed freight service, a greater gear reduction is desired between motor and drum than is obtainable in the worm gear alone. An additional reduction is then obtained by mounting a pinion driving a gear on the drum, as shown in Fig. 4.

For very tall buildings it may not be feasible to use a winding drum type of elevator machine because the amount of cable involved requires too large a drum for the limited space available. For this class of work the traction type of winding machine is used. With this machine the cables are not reeled onto and off from the drum. The cables between car and counterweight simply pass partially around the drum, driving torque being transmitted to the cable by friction or traction between the cables and drum. Idler sheaves are supplied to give the desired span from counterweights to car and to increase the arc of contact on the drum. The principle of arrangement is shown by Fig. 1 C. Sometimes the car is equipped with sheaves and the cables so arranged that the car travels at half the speed of the cable, as shown in Fig. 1 D.

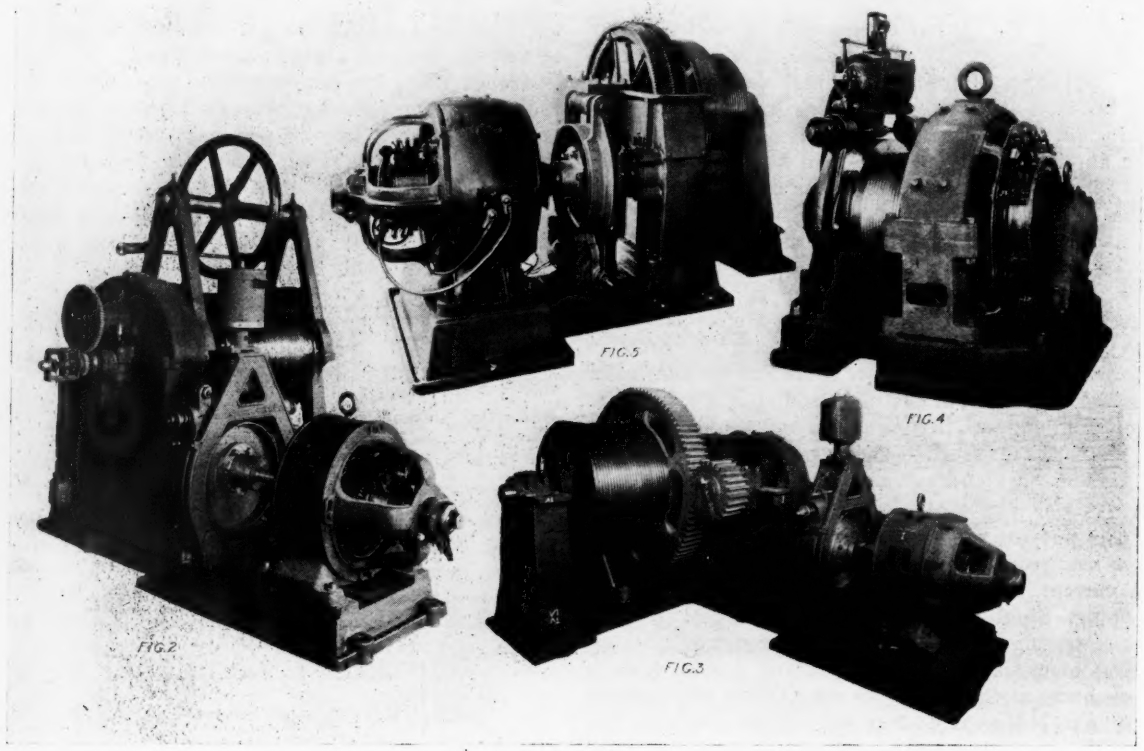


FIG. 2. SINGLE WORM GEAR DRUM TYPE ELEVATOR. MACHINE WITH DIRECT CURRENT ELEVATOR. FIG. 3. DOUBLE WORM DRIVE WITH ADDITIONAL SPUR GEAR REDUCTION. FIG. 4. DIRECT CONNECTED TRACTION TYPE ELEVATOR. MACHINE WITH DIRECT CURRENT MOTOR. FIG. 5. TRACTION TYPE ELEVATOR MACHINE.

Direct Current Drives

The motors used for elevator service are of several types. Both direct and alternating current motors are used but direct current equipments predominate. These will be first considered.

The great majority of equipments utilize winding drums driven through worm and wheel. It will be seen that this arrangement permits the use of fairly high-speed motors. Equipment of this general type are utilized for rope speeds from about 100 to 400 ft. per min. For the lower speed equipments, it is not necessary that very accurate slow speeds be obtained for approaching landings. For such work a compound wound motor is suitable, the control being arranged to

short-circuit the series field winding during periods of full speed running. The compound winding is utilized to obtain good starting torque. Slow-down is obtained by introducing the series field and starting resistance and by shunting the armature with a resistance. The control is arranged to cause dynamic braking in the off position for accurate stopping. Motors for this service are commonly rated at about 800 r.p.m. Due to this relatively high speed, an equipment of this type is comparatively low in first cost. It is well adapted to slow speed service and is used where investment cost is of prime importance and when relatively infrequent service offsets its low efficiency.

An equipment having a rope speed of 200 ft. per min. or above requires more accurate slow-speed operation. This is attained by using an adjustable speed motor having a speed ratio of 2 to 1 or 2.5 to 1 by field weakening. The larger the field control speed ratio the higher the cost of the motor, but the better the speed control and the higher the starting torque per ampere input. These motors are usually rated about 400/800 r.p.m. During acceleration, the field is fully excited to give high torque. After the starting resistance is cut out, the field is weakened by gradual introduction of resistance into the field circuit. Slow-down is obtained by strengthening the field and by introducing the starting resistance and shunting the armature, if necessary.

The adjustable speed motor is higher in first cost than the single speed motor. It affords better speed control and higher efficiency. Higher starting torque is developed per ampere input due to the strong field. The starting resistance is in circuit a relatively short time and the resistance losses are therefore less. The power input to accelerate an adjustable speed elevator motor is about two-thirds of that required to obtain equal acceleration with a single-speed motor. Moreover in slowing down by strengthening the field, some power is regained by regeneration. The starting resistance may be cut out in a smaller number of steps with less contactors, retaining smooth acceleration. The resistance losses incident to slow speed operation with shunted armature are higher in the case of the single-speed motor. With the two-speed motor these losses are small, particularly if no armature shunting resistance is used. Adjustable speed equipments are used where high rope speeds render their more accurate speed control necessary, and where frequent service renders the higher operating efficiency of sufficient importance to justify the greater first cost.

Regenerative Action

It is necessary that an elevator motor develop torque in the direction of its rotation when the car load in hoisting is greater than the counterweight or when a light car is lowered. When hoisting a light car or lowering a heavily loaded car the load is overhauling so that the motor must act as a generator and exert a torque opposing rotation. In order that the speeds may be approximately the same under any conditions, it is necessary that motors employed for elevator service have good speed regulation so that a change from motor action to generation action takes place without an appreciable variation in speed. It is for this reason that the series field winding of a compound wound motor is short-circuited during the running interval.

Elevator service is a fluctuating load involving frequent starting and stopping peaks. It is therefore desirable that interpole windings be used, particularly with the adjustable speed motors, to insure good commutation. It is also well to have the interpoles laminated so that the flux values will follow the load fluctuations closely.

The motors used for traction type elevator engines are direct connected to the drum or drive through a single reduction of helical gears. A direct connected motor of about 65 r.p.m. is required to drive a 30-in. drum to give a car speed of 500 ft. per min. with 1 to 1 roping. With 2 to 1 roping a higher motor speed may be used. Motors for gear drive of traction elevators range in speed from 200 to 600 r.p.m.

Traction elevators are used with rope speeds ranging from 350 to 700 ft. per minute. Accurate speed control is necessary. Therefore the motors are arranged for speed adjustment by field weakening; however, the speed range is usually confined to about 1.2 to 1 for direct-drive motors and 1.5 to 1 for geared motors. The slow-speed motor represents a large item of cost, proportionately greater than in the case of the high-speed motor driving through worm wheel. Moreover the fields of the slow speed motor are sluggish so that a high field ratio would prevent quiek acceleration. The armature inertia of the traction drive motor is only 8 per cent of the total inertia whereas the armature inertia of the high-speed motor with worm gear drive is about 50 per cent of the total inertia. The armature of the slow-speed motor is made short and of wide diameter to give a compact arrangement with minimum overall length. Interpoles are omitted as unnecessary because of the slow speed and undesirable as introducing ohmic drop and affecting speed regulation. The control is similar to that employed with the adjustable speed motors driving winding drums. Shunted armature points are employed for slow speed operation. Due to the high rope speeds particularly accurate control is desirable.

The types of alternating current motors used in elevator practice, together with a discussion of methods of control and points to be considered in selecting motors, will be taken up in a subsequent article.

Emergency Lighting

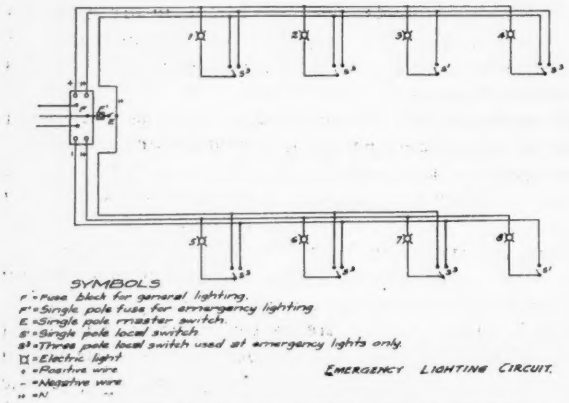
By William Sheriff Jones

THE PROVISION of emergency lighting, in power plants and other buildings, is a matter of considerably more importance than is usually recognized. To be able to push one button, located at a convenient point, and, by so doing, illuminate certain rooms or spaces in the building is an arrangement the value of which is readily realized.

Quite often, in emergency systems of lighting, it has been the practice to provide separate circuits and separate fixtures in addition to those required for the normal illumination. This has resulted in a dual lighting system in the spaces where emergency lights are required and, aside from the expense of such an arrangement, it has the added disadvantage that the emergency circuit is not sufficiently used to be assured of proper operation when the emergency occurs. Frequently, such circuits have been out of order several weeks or months and the

trouble was not made evident until there was occasion for their use.

Some eight years ago the writer devised a scheme of emergency lighting for fire engine houses. With this


SYMBOLS
F = Fuse block for general lighting.
F' = Single pole fuse for emergency lighting
E = Single pole master switch.
S = Single pole local switch
S³ = Three pole local switch used at emergency lights only.
□ = Electric light
+ = Positive wire
- = Negative wire
N = N
EMERGENCY LIGHTING CIRCUIT.

WIRING DIGRAM OF EMERGENCY LIGHTING CIRCUIT

scheme no special fixtures are required but the fixtures which are considered as emergency lights are controlled by local three-point flush switches instead of the regular single pole switch. The master switch, which controls the emergency lights, is a standard, single-pole, flush switch located at the operator's desk. All of the emergency lights can be thrown on or off at will as long as the master switch is open, the same as other lights throughout the building; but when the master switch is closed all lights on the emergency circuits are lighted and can not be turned off except by the master switch.

As the emergency lights are used normally every day any trouble with any one of the lights will make itself apparent immediately and the trouble will, as a rule, be remedied right away.

The accompanying sketch indicates the wiring connections for a system such as above described in which certain of the regular lights are used for emergency. This arrangement may be used to advantage in residences with the master switch at the head of the master's bed or automatically operated by a burglar alarm system. It may also be used for apartment or hotel corridor and stairway lighting so as to operate certain necessary lights in case of fire, and for numerous purposes other than in the power plant. The only additional cost above that of the regular lighting system is for the one extra wire connecting from the master switch to the third point of the three-point switch and the slight additional cost of the three-point switch above the single-pole switch.

Commutator Insulation Failures

SUGGESTIONS REGARDING THE CARE AND REPAIR OF COMMUTATORS. BY J. L. RYLANDER

COMMUTATOR insulation failures are very annoying and aggravating. In a large plant, these troubles usually do not come singly. One motor after another may fail. When the motor is again placed in service after being repaired, the trouble may occur again after a period of operation that is entirely too short. Sometimes there is an epidemic of commutator trouble. The reason is that where certain conditions exist, there will be trouble and, as these causes often extend to hundreds of motors in the same plant, many motors will be affected. There are probably more of these failures on motors operating in or around steel plants than on all other applications combined. A failure in the commutator may be the cause of short circuits in the armature winding which may necessitate complete rewinding.

A well built commutator, properly maintained, will give little operating trouble. Commutator failures are usually the result of the following general conditions:

1—Carelessness and neglect,

2—Lack of understanding of the principles underlying the construction and operation of the motor,

3—Indifference of the operator, who is more interested in output than maintenance expense,

4—Improper construction of rebuilt commutators.

Practically all commutator insulation failures are caused by one or a combination of the following causes:

1—Rough burrs on the bars or clamping rings.

2—Excessive voltage between bars due to turns being cut out of armature, etc.

3—Carbon dust or other conducting materials under the bars.

4—Oil between the bars or at the edge of the bars, causing pitting which eventually burns through the mica V ring.

5—Mill dust, carbon dust, copper slivers, moisture and oil on the exposed parts of the V rings, causing insulation failures, unless precautions are taken to protect them and keep them fairly clean.

Usually, the fundamental causes are due either to oil or to conducting dust, although there are many contributing factors. The oil may have come from the bearings, if there are no oil throwers on the shaft, or it may have been spilled on the commutator accidentally when oiling the bearings, or oil or some other lubricant may have been applied to the surface of the commutator bars by the operator with the object of improving commutation.

Mill dust or iron ore dust, or the carbon dust from the brushes, if allowed to collect in some pocket or crevice, bridges across the mica between two bars and causes failures. Dust usually accumulates on the exposed insulation at the ends of the bars and even works its way under the bars. Small slivers of copper caused when turning or machining the copper, or when undercutting the commutator mica segments, may be the cause of trouble.

COMMUTATOR MATERIALS AND CONSTRUCTION

THE KIND of mica and copper used, and especially the dimensions and fits of these materials with each other have more to do with commutator insulation failures than is generally realized. When it is considered that a variation of 0.001 in. on each mica strip or on each commutator bar makes a 0.031 in. difference in diameter for a commutator with 100 bars and may be

double that if the variation occurs with both the bars and mica, it is evident that precautions are necessary to build a good commutator. The copper bar grooves, the mica V-ring, and the V of the iron bush all require the same diameter at the point of the V. It is also vital that they have the same degree of taper. When these parts do not fit perfectly with each other and are then clamped together, there will be small crevices which may be observed only by making a very careful examination. Although small to the eye, these crevices will be large enough to permit fine particles of dust to find their way under the bars.

The copper from which the bars are made should be hard drawn and not soft copper which has been machined to shape. Soft copper does not have the good wearing quality of hard copper. It is also liable to bend up at the ends and allow small crevices, as well as to cause chattering of the brushes.

The built up mica should have the best compound and the proper amount of it for sticking the mica laminations together. Some compounds that are used do not stick the mica to the bars, which will increase the probability of loose mica.

The writer recently had occasion to examine some commutators made by a concern which "remakes commutators" and furnishes parts for many crane motors and mill motors. These commutators were made with the following modifications from the original construction. The mica segments were 0.031 in. thick instead of 0.025 in., which would increase the chance of high mica. The compound used for sticking the mica laminations together would not stick to the copper bars. Soft copper machined to shape was used for the bars instead of hard-drawn copper punched with a die. The machined V's were not accurate, and one end was 1/16 in. smaller in diameter at the gage point than it should have been. This shows the importance of having all repair parts properly made from accurate drawings, and of having suitable dies and tools.

When assembling the commutator, conducting material may have been deposited in the assembled bars or perhaps be partly buried in mica V-rings. When turning commutators there may be small slivers which have burred over. If the commutators have been undercut, the cut at the end of the mica segment may have been pulled instead of cut clean, which makes a frayed corner.

Effect of Copper Slivers, Carbon Dust, Mill Dust or Ore Dust

Heating of bars is probably due to bridging over the mica segments between the bars by small particles of copper, carbon or other conducting dust. This trouble may occur on either the front or rear end of the commutator or on the parts under the bars. If the rear end of the commutator is not fully protected, by packing it solid with insulation, there will probably be more trouble there than on the front end, because conducting dust which settles on the armature, cannot be removed from the rear V-ring.

Effect of Oil

Pitting between bars is probably traceable to the presence of oil, grease, or other lubricant on the commutator. This trouble from oil or lubricants usually affects the front end only. If the V-rings become filled with oil they become soft and gummy. The capillary attraction of the oil draws in the carbon dust from the brushes and also other conducting particles. Although oil itself is a good insulator, it adds no insulating qualities between two bars if there is a particle of conducting material bridging across the mica strip, even if the oil surrounds the particle of dust. Oil has two very harmful effects when in or on a commutator. The first is that the oil dissolves the compound used between the mica splittings. The second is that an arc breaks up the oil into carbon, a gas and a liquid which makes the path more susceptible to a second discharge. This is so important that at least one large manufacturer has a metal plate prominently fastened directly above the commutator, stating "Caution—Use no lubricant on commutator."

Varnish on Commutators

A smooth, hard, glossy, varnish surface on the end of the bars and on the insulation which protects the projecting part of the mica V-rings, gives excellent protection. However, care must be taken in applying it, for liquid varnish in the commutator where it will not dry is harmful. Liquid varnish does not dissolve the bond in the mica, but it does act much the same as oil when subjected to sparking.

Remedies

1—Obtain copper bars, mica segments and mica V-rings of the best material and absolutely correct dimensions. Be sure the copper, the mica V, and the iron bush fit accurately. If the commutators are to be undercut, make a clean cut at the end of the bars so as not to leave a frayed corner on the mica strip. Do not undercut a commutator until after it has been trued up by turning, as the turning drags the copper more or less.

2—Make sure that there is no dirt in the copper V or on the mica V when assembling. Sandpaper lightly the part of the mica V which rests against the bars immediately before putting it in place, so as to remove any particles of dirt that may have accumulated on it, and do not lay it down on anything that is not absolutely clean. Clean out the copper V immediately before inserting the mica V.

3—If the commutator is of the solid neck type, the rear end can be effectually protected by filling the space from the mica V-ring to the bottom lead with insulation. The top should also be protected by placing an insulating hood over the winding which extends over the leads and onto the commutator neck.

4—If the motor is totally enclosed keep the handhole covers on at all times.

5—Apply over the projecting part of the mica V-ring three turns of surgical tape which has been treated in varnish. Sew all three layers so as to join the start and the finish. Apply about five coats of varnish. Each coat of varnish must be thoroughly dry before applying the next coat. A baking varnish is preferable to an air drying varnish. Apply this same insulation to the rear end as well as the front end if the space from the mica V-ring to the bottom lead is not built up solid with other insulation in such manner as to seal it. Apply

this insulation so that there will be no pockets formed next to the bars, and also at the end of the mica V so that nothing can enter between the mica ring and the iron bush. This will make a smooth, hard, glossy surface. Also apply five coats of varnish to the ends of the bars.

6—Keep all oil, grease or other lubricant away from the commutator.

7—Do not allow any varnish or shellac to get into the commutator under the bars where it would not dry.

8—Brush off the dust from the insulation at the ends of the bars occasionally.

Adherence to the above suggestions at all times will reduce commutator insulation failures to a minimum.—The Electric Journal.

Grain vs. Flesh Side for Leather Belts

DURING the latter part of the past summer tests of the capacity of the grain and flesh sides of leather belts were begun by the Leather Belting Exchange in its Research Laboratory at Cornell University. They were under the direction of R. F. Jones, director of the laboratory. Covering a period of more than 2 mo., continuous tests were run on the testing apparatus belonging to the Leather Belting Exchange, which is being operated under the supervision of Cornell University, using five 4-in. single belts, 30 ft. long, of different manufacture. All five belts were run long enough previous to the experiments to have been thoroughly "run-in," and had reached a condition of constant capacity when the records were taken.

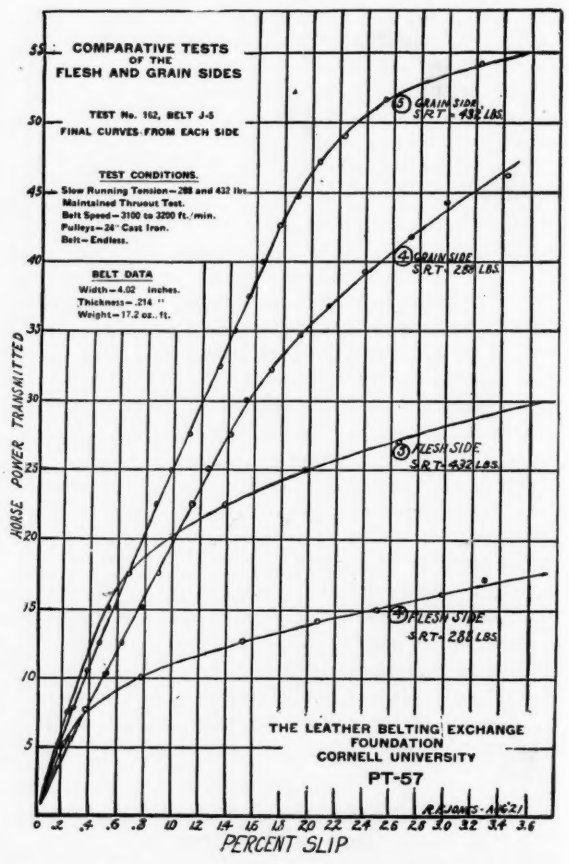
The method of procedure was to take horsepower readings from the belts first when running on the grain sides, and then when running on the flesh, the power being gradually increased until about 4 per cent slip had been reached.

In considering the results, it must be remembered that a leather belt is at its lowest point of capacity when new, largely because of the elasticity of the leather and the newness of its surface. Leather belts are well stretched in the process of manufacture, so that when the belt is put on the pulley there may be as little stretch as possible consistent with thorough lubrication and retaining the natural life or elasticity, which is such a valuable property of the leather belt. When a new leather belt is placed on the pulleys, however tightly, it will elongate under load. But after the tension of the load has been removed it returns very nearly to its original length. This stretch is an annoyance when installing a new belt, but it is of the nature of a safety valve, protecting both belt and machinery.

The newness of the surface, however, makes it necessary to "run in" the belt when testing it; that is, to run it for a sufficient time to permit the belt to attain its maximum capacity in transmission. As an illustration, one belt under test at the Cornell Laboratory transmitted 12 hp. when first put on the pulley at a slip of 1.2 per cent. After 5 hr. running it reached 19 hp. with the same percentage of slip and the same tension. At the end of 13 hr. it transmitted 24 hp., and reached 31 hp. after 20 hr. with a slip of 1.6 per cent. According to horsepower tables, its scheduled transmission should have been 26 hp.

A summary of all of the results is clearly in favor of the grain side from the standpoint of power transmission. In fact, it may be concluded from it that under reasonable shop tension, the flesh side will average only 50 to 60 per cent as much horsepower as the grain side. At higher tensions the flesh side will do better, averaging from 50 to 100 per cent as much power as the grain, depending upon the belt, the tension and the conditions of service.

A curve plotted from the readings taken when the belts were running on the flesh side is similar both in shape and capacity to that given by many of the leather belt substitutes. All that can be said of the test belts run on the flesh side is that the data obtained from them were more uniform than that taken when they were running on the grain.



PERFORMANCE CURVES SHOWING EFFECTS OF USING FLESH AND GRAIN SIDES OF BELTS

Using the horsepower transmitted and the percentage of slippage as the co-ordinates, on chart PT 57, which is representative, the grain tests showed an almost curveless gain in horsepower up to 53, when the slip reached about 3 per cent for belts running at a slow running tension of 432 lb. In the case of the test belts operated at a slow running tension of 288 lb. the 3 per cent slippage was reached at about 44 hp. With the belts running on the flesh side, however, the 3 per cent slippage mark was reached at 28 hp. when operated at a slow running tension of 432 lb., and at 16 hp. when the tension was 288 lb.

Constructing a Pantograph

EASILY CONSTRUCTED PANTOGRAPH USEFUL IN REDUCING, ENLARGING OF COPYING DRAWINGS. BY VICTOR H. TODD

THE PANTOGRAPH is an important and useful instrument for reducing and enlarging drawings such as maps, or figures where it is essential that the new drawing is exactly like the old one. Since its value depends on its accuracy and the absence of all lost motion in the joints, it is often quite expensive; however, if one is handy in using carpenters' tools, a very good pantograph may be constructed easily and cheaply.

Referring to the diagram, it will be readily seen that the device consists of four parts, resembling rulers, jointed together at the extremities, and two sliding carriages, having provision on their under side for carrying a pencil; and a thumb screw on top to clamp them to

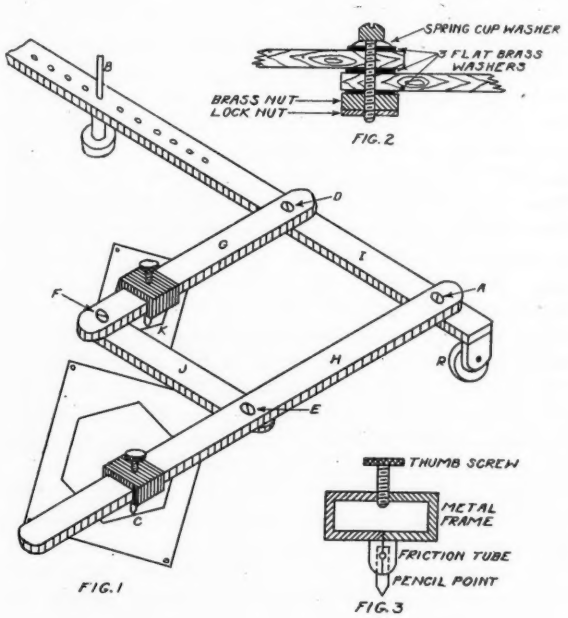


FIG. 1. SKETCH OF HOME-MADE PANTOGRAPH
FIG. 2. SHOWING CONSTRUCTION OF JOINTS
FIG. 3. SECTION THROUGH PENCIL SLIDER

the frame. The pieces AB and AC are each 2 ft. 4 in. long. Their cross section is 1 in. wide by ¼ in. thick and should be made of carefully planed, seasoned hardwood.

The distances AD, AE, FE and FD should be exactly equal and about 12 in. long.

If a 10-32 tap is available, the holes in the top pieces, G and H are drilled with a clearance drill (No. 14) and the bottom pieces, I and J, drilled with a tap drill (No. 20) and tapped with a 10-32 thread. The four joints are then made as shown in Fig. 2, using a spring washer to take up the lost motion and an extra nut or lock washer to prevent loosening. The screws and nuts often found in the carbons of old dry batteries are admirable for this purpose, if the holes are drilled accordingly.

The fulcrum B is a leaden weight, approximately 4 in. in diameter, with a wooden center which makes the stick I the same height as the pencils make the sticks G and H. Into this wooden center is driven a needle and the holes in stick I, which are drilled ½ in. apart, are drilled so they make a snug clearance fit over the needle. It is advisable to place one or two thin brass washers between the stick and the fulcrum to prevent excessive friction.

The sliding carriages are preferably made of metal but may be constructed from wood if desired. They must slide easily over the sticks G and H and be able to permit of being locked in any position by the set screw. On the bottom is arranged a little spring holder to carry a pencil point. A cross section of the slider is shown in Fig. 3. If the slider is made of metal the pencil point holder should be made of a piece of brass tube, soldered to the metal frame, and slit down the side to form a spring fit over the lead, or a short lead pencil itself may be inserted in the slider by drilling a hole of sufficient size.

The little wheel at R can easily be constructed from wood or metal and fastened to a wooden projection (glued to I) by a wire lath-nail or a convenient screw.

To reduce a drawing one-half the original, set the instrument so that a hole at B (which is in line with the points of the pencils at C and K) is just as far from G as that point is from K. In other words, the distance BC is twice BK, but points B, K and C must be in a straight line. The distance B to C represents the original and B to K the reduced copy. By varying either, any amount of reduction may be made.

Instead of two pencils a piece of hard wood sharpened to a pencil point may be advantageously used in C when reducing and in K when enlarging.

When passing from point to point on the original and not wishing to make a mark on the copy, the pencil may be raised temporarily by raising the joint at F.

It is advisable to use a rather hard lead pencil sharpened to a fine point on sandpaper and if much drawing is to be done provision should certainly be made for quickly removing the point so it may readily be sharpened.

This model may easily be adapted for engraving by mounting a small electric motor with a special drill in place of the lead pencil. The motor runs continuously and engraves exactly as guided by the original copy. In engraving letters and numbers, a good set should be bought, after which any number and any size can easily be made.

Correction Note

OUR ATTENTION has been directed to an error which appeared on page 1017 of the Oct. 15, 1921, issue in the article entitled "Determining the Polarity of a Wire." This article states that the most bubbles arise from the positive wire. This is not the case and should have read, "The wire from which the most bubbles arise is the negative wire."

IN ENGLAND, during the last 14 mo., new generating stations have been authorized to a capacity of 150,000 kw. and extensions to 547,000 kw. Interconnecting lines are also planned looking toward a super-power system development.

Trouble Hunting---XI

IN WHICH I ASSUME CONTROL OVER A VERY CONSIDERABLE SIZE WRECK. BY JOHN PIERCE

AFTER we had got down from the box car for which I had paid a "pullman" price, we began to wonder how we would ever get down into the city. We found, directly, an old fashioned two-seated buggy that looked as if it would never make the trip, drawn by a pair of long frames that at one time may have been ponies. I asked the driver where he was going down and he pointed to some places on the rocks that appeared to have been polished and assured us we would be able to make the trip all right. I was doubtful, but as we had to get down, we climbed aboard. The brakes didn't look any too good to me, but he fastened some wire cable to the back axle and tied them around some rocks. I observed three ropes on either side of the upper frame of the boat, but asked no questions regarding them, thinking perhaps I'd learn by observation.

Away we went, the rocks dragging behind and holding us back in fine shape. Three men ran alongside on each side of the rig and held the ropes. I found soon enough that these were what prevented us from tipping over and I feared greatly that the ropes were old and rotten and would surely break. They did not, and in the course of half an hour's joggling we reached bottom. I found this beautiful—at a distance—old town had been a place of 28,000 souls but was now ruined shamefully and contained but 3000, not counting the dogs.

In every house and building were thousands of marks of bullets, and blood was, and is, still smeared over many of the walls. In its prosperous days the town had supported 13 large churches and two schools. The churches were magnificent buildings and had a priest or secretary, and six servants in the priest's house. Over all was a head priest who had no individual church, but was in control of them all. The schools had each a "master" who received one peso per day. The churches were still all operating, but the schools were defunct.

I met the father in charge a day or two later and asked him if it were not better to establish 13 schools and maintain but two churches. He asked why and I replied that the lack of education was terrible and the children should be educated.

He replied, "But, son, the moment education begins to take hold of these people the priest begins to lose his power over them."

The 3000 people of this place were almost entirely depending on the work opening up at the mines, as everything else was ruined, and as there had been no crops for years, and no stock, this work was their last chance.

My predecessor had been a shaft digging contractor, and did not claim to know very much regarding his duties as master mechanic, but he had succeeded in spending 400,000 pesos in a year's time and had accomplished not a single thing. I am, however, getting ahead of my story.

I was taken by the superintendent on my arrival at the office to a mess hall, or, as we call them in Mexico, the club house. Here we were given elegant rooms, all fitted up nicely, and equipped with a servant. The company paid for all these things and they were furnished gratis to the white men, they only paying the nominal sum of one dollar per person per day for the entire thing, including first class food. Having dreamed great dreams of the future, the manager had leased two great buildings and had established two fine club houses, built a tennis court, and fixed things up in fine shape. The building where I was quartered cost $7.50 per month and the other one $8. They both contained 15 beautiful large rooms each, a general club room, and a "hatio."

The following morning I was given a fine imported saddle horse and told that henceforth the horse would be for my personal service alone, and we went forth to view my new kingdom. I found I was to be in charge of everything above ground, the mine superintendent to be in charge of everything below ground except the pumps, and such other equipment as I should install, that becoming mine also, once installed. There was a large ore mill being taken down piece by piece to be used in the rebuilding of the main works. There was a very large mill designated "the sawmill," this had been a very fine mill in its time, equipped with lathes, planers, saws, band saws, and all kinds of woodworking machinery. We then inspected the lake, which was not a lake any longer, as the rebels had blown up the dam and let the water out. Next we visited one of the first of the mines that were worked in that part of the country, over 600 yr. old. This had the warehouse intact, though the wares were sadly missing. Next we went to the old machine and blacksmith shops, the boiler shops, the assay offices, the oil supply stations, the cable rooms, and the old engines, or rather what remained of them. From there we visited the central works, which is the point where I was to rebuild the first equipment and get it under way. Here were located the buildings for the new machine shops, and here I found three blacksmith shops, two large carpenter shops, the main hoist room, auxiliary hoist rooms, boilers, pumps and engines, all scattered around and heaped up. It was really the most disgustful sight one could imagine, with pieces of old equipment and pieces of new equipment, and everything in the world all thrown helter skelter, and in a jumbled mess. From this place, which made me feel that I had got into one awful place, we went to the other four properties over which I was to have jurisdiction.

I had never in all my life seen such a conglomeration of machinery, nor a more completely wrecked plant. One other thing at this place made conditions very bad—that is, they would have been hard had I not done as I did. There was with the company a man who was and had been superintendent of this property for 15 yr. or more. They employed another superintendent, giving him full power and authority, but left the other one on, *giving him full power and authority also.*

Therefore the body had two heads. One could order one thing done and, naturally, a fellow would start to do it. The other fellow could order it stopped and, as naturally as before, a fellow would stop it. To make it worse, the two men hated each other, each being jealous and each feeling that it was not right to place him in such a position, but each determined to outlast

the other. It will be readily seen that with things in this shape, nothing could be accomplished, and nobody need wonder why my predecessor had got nowhere. The only thing the two men were agreed upon was that we should get the water from the mine as quickly as possible and start work. Each had his own ideas as to how it could and should be done.

After a consultation with the two of them present, I learned what they wanted; then I declared myself. I told them that neither had hired me, neither knowing I was on my way until I reached there with my credentials, and therefore neither could fire me, and that I would listen to suggestions from either one, but would take orders from neither; that I would do the best possible to get the work under way, and if I had to requisition anything, I'd have the first one of them that I met forward my order for delivery, and both being engineers and draftsmen I would, in case I wanted anything along that line, call on the handiest of them to do it; but otherwise I would assume full control of everything in my line. This stumped them both for a while, but they agreed to it finally, and then first one and then the other came to me privately and said I'd be a fool to have anything to do with the other fellow.

Well, I looked the situation over and took soundings. I found a mine 2000 ft. deep. I found the limits of mine property to be 2 mi. in length, and 1 mi. wide. I found that the drifts shown on the map were from 50 to 100 ft. wide, and from 50 to 300 ft. high; that the mine had been worked for over 300 yr. in most places and 600 in some—the older workings being by the Spaniards and Indians, and shallow workings. I found that, in all, the maps showed 92 mi. of these workings and 1850 ft. of water was standing in the mine. I sure wondered how I was going to get it out, especially as it came in at a normal rate of 200 gal. per min. when the water was down and the mine working. Casting about, trying to decide where to begin, I found that there had been three 500-hp. hoists in use, one at this place and one at each of the other nearest two mines. These engines were almost identical, and the differences in sizes of the various pieces of each were so small that it was hardly noticeable until one went to assemble them; then it was very apparent that something was wrong.

The first move I made was to move the lathes, planers and other machines into the machine shop and set them up, hang the shafting and countershafting, and get them all in shape to work. This of course took several days and while we were doing it, I had other men at work trying to locate the tools, gears, etc., which belonged to each machine.

I had quite a bit of trouble finding any tools, though nearly all the gears, and the tool holders were located. The follower rests of both lathes were broken, and parts of the dies of the both machines were gone, while all the dies for the pipe machine had been thrown away. In this I was fortunate in that at the warehouse I found a complete new set of dies. The next thing was to get the blacksmith shops in a little better shape, so I started in on one, threw out all the tools, and rebuilt it.

The bellows arrangement of this shop was a new one on me. The bellows was mounted overhead, upside down, and had a rope running over a pulley which a big husky man pulled on, in jerks, to make a little wind. I put a regular high-speed hand operated forge fan to work that made twice the air, and could be handled by a boy. This, in itself, was only temporary, as I was intending to, and did later, run an air line from the receiver to the different forges. The reason for not doing it at this time was because as yet we had no air.

After the one shop was fitted up, I put the men to making tools and wrenches for the machine shop, and started in rebuilding the other two shops.

Both superintendents were after me about the boilers and engines, that the compressors and hoists might be put to work, but I preferred to make haste slowly, and have things moving somewhat systematically when we did move.

After I had the other two blacksmith shops in order there came from the general offices an order to delay work at the main plant a while and get to taking ore from three others working higher up in the mountains so that production would help the expenses. This was to me a relief, for I needed tools, lots of them, and I could be fixing up the smaller places while waiting on the tools which simply must be had for the main property. I sent in an order, and received the tools, by express, in due time. The bill for tools, steel, and other things, not a thing which was not needed, was $25,000. This may seem like a large order; it was a fairly large order, but when you consider that to get such things into Mexico you have to pay about twice what they cost in the States—you have to pay custom fees, consular fees, and many other little fees—a thousand dollars buys but little. I also ordered at this time something like $2000 worth of packing, pump valves, springs, studs, and several pump liners and plungers complete. While waiting for these, I started getting things in shape for working our first copper diggings.

BILLS ARE now before both houses of Congress to authorize the establishment of free zones in ports of the United States. These are H. R. No. 2228, introduced by Mr. Nolan of California, and S. No. 2391, introduced by Senator Jones, of Washington. The Chamber of Commerce of the United States is taking an active interest in the enactment of this legislation, the membership of the National Chamber in Annual Meeting having declared in favor of this governmental facility for business.

Free zones in our ports will give our merchant marine an increased share in the carrying trade of the world; will bring added business to our banks, insurance companies, freight forwarders and warehousemen; will provide a wide consignment market for dutiable wares and materials from which American manufacturers as well as American merchants will benefit; and, finally, the free zones will bring vast improvement over the present facilities of bonded warehouse and drawback, simplifying customs procedure.

In the Senate Bill in its latest form, the authorization of manufacturing within a free zone is omitted. Also prohibition of more than one free zone in any one port within a State, is carried both in the pending House bill and the Senate bill. To get the greatest benefit, manufacturing for export should be permitted within the free zones, and establishment of zones should be possible wherever and to such number as will best contribute to the interests of our commerce and industries.

Lifting a 225-Ton Engine Frame with Three Cranes

METHOD OF PROPORTIONING LOAD ON CRANES AND DETERMINING POINTS OF SUPPORT. BY F. W. BRADY

THE ERECTING engineer is constantly engaged in giving the world a lift. He is a modest man, however, and does not perform his lifting stunts for a percentage of the door receipts, as does the spotlight variety of lifters. Nevertheless, his engineering stunts often have a large number of interested spectators.

Lifting a 225-ton engine bed as shown in the sketch, Fig. 1, is a problem of special interest to mechanics because of its three-fold features; the large size, the per cent of overload, and the method of hitching. The size of the load always attracts attention; but this, after all, was not the leading feature. The lifting and carrying of this engine bed was done with two 60-ton cranes and one of 40-ton capacity. It will be seen that the

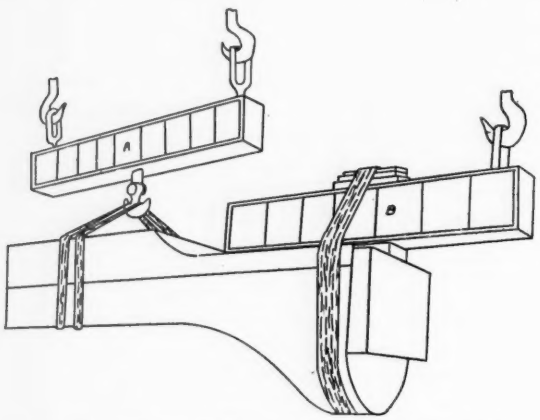


FIG. 1. LIFTING A 225-TON ENGINE FRAME WITH THREE CRANES

cranes were overloaded, and a little computation will show how much. Thus, the nominal capacity of the three cranes is 60 + 60 + 40 = 160 tons. As the estimated weight of the load was 225 tons, the overload was 225 — 160 = 65 tons. In percentage, this overload amounts to $\frac{65}{160} \times 100 = 41$ per cent nearly. When the crane construction is of the best, and the cranes have a safe overload rating, such an undertaking is reasonably safe. At any rate, this lift was made in a satisfactory manner.

The hitching problem involved more calculations than did the problem of the percentage of overloading. The figuring is simple, however, as only the easiest processes of arithmetic are required. It is a good plan to locate the center of gravity of the load and to use this as the starting point when proportioning the load on two or more cranes. This may be done readily, either by making direct measurements or by the use of the drawings. Where the load consists of a simple form like a cylinder or a prism, everyone knows that the balancing point is at the middle of its length. But where the load is made up of two or more forms, such as cones, pyramids, frustums, etc., the center of gravity of the combination must be figured. This is quickly done by using the rules given in handbooks on Mechanics. Take the case of two cones attached base to base as shown in Fig. 2. The center of gravity of a cone is located ⅓ the height from the base. If the heights of these cones are 6 ft. and 12 ft., then the individual balancing points are 2 ft. and 4 ft. respectively from their common base. As the volume of a cone is given by the formula $(3.1416 \times R^2H) \div 3$, that of the smaller cone in Fig. 2 is $(3.1416 \times 9 \times 6) \div 3 = 56.5$ cu. ft. The larger cone has twice this volume, or 113 cu. ft. The balancing point of the combination, which is the point at which to locate the sling for a single lift of the lead, is found by multiplying the volume proportions 1:2 by the lever area of each.

$$1 \times T = 2\,(6 - T), \text{ or}$$
$$3T = 12, \text{ or}$$
$$T = 4 \text{ ft.}$$

If the load is formed of two pyramids instead of the cones, the center of gravity of each pyramid is ¼ of its height from the base, and the volume of the pyramid is ⅓ the area of the base multiplied by the height, and the common balancing point is then figured in the same way as for the cones.

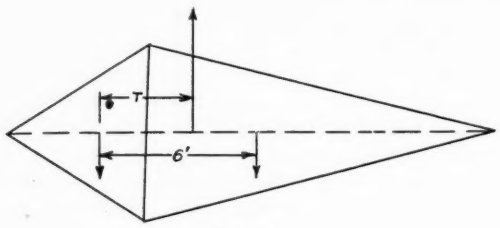


FIG. 2

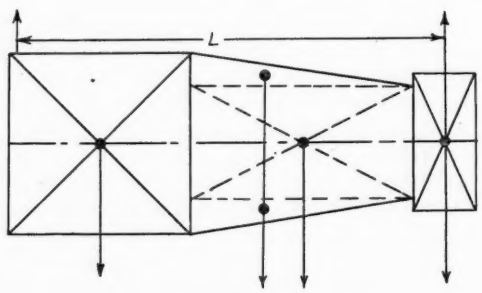


FIG. 3

FIG. 2. THE BALANCING POINT OF COMBINED CONES AND PYRAMIDS

FIG. 3. PROPORTIONING THE LOADS ON TWO SLINGS

As the most common form of machine frames is the frustum, that is, a pyramid or cone with its top cut off, the method of finding its center of gravity must be used. The distance of the center of gravity of the frustum of a cone or pyramid from the base is expressed in the following formula:

$$\frac{h\,(A + 2\sqrt{A \times a} + 3a)}{4\,(A + \sqrt{A \times a} + a)}$$

in which h = the height of the frustum, A = the area of the base, and a = the area of the top.

After finding the center of gravity of the load the next step in the problem is to proportion the loads on the two slings. This proportioning may be either for equal loading or for capacity loading of the cranes. This is done by the rule of moments. A moment in mechanics means the product of a force by its lever arm. This principle will be explained in the solution of the problem of the large machine frame shown in Fig. 3.

The front view consists of a 5 ft. square, a 5 ft. by 3 ft. by 6 ft. frustum, and a 2 ft. by 4 ft. rectangle. The weights of the three divisions may be represented by their areas, which are 25 sq. ft., 24 sq. ft., and 8 sq. ft., respectively. The actual weights in pounds are found by multiplying these areas by the thickness of the casting and by 450. The center of gravity of each of the rectangles is located at the middle where the diagonals cross. The frustum may be separated into a 3 by 6-ft. rectangle and two 2 by 6-ft. triangles. The center of gravity of each triangle is ⅓ its height from the base, or 2 ft., as previously explained. The horizontal center line of the casting may be considered as loaded by these four areas suspended at points representing the center of gravity of each area as shown. The total area is $25 + 6 + 18 + 8 = 57$, and if equal loading is required on two cranes, each must carry $57 \div 2 = 28\frac{1}{2}$.

Suppose one crane would be located at the left end of the large division, then the problem is to find the location for the second crane in order to give equal loading. By the principle of moments, if the left end of the load be taken as a fulcrum or pivot, and then each weight or area be multiplied by its distance from the pivot, the clockwise turning effort will be found. This effort is resisted by the lift of the second crane multiplied by its distance from the fulcrum. Therefore, the following solution applies:

$(25 \times 2\frac{1}{2}) + (6 \times 7) + (18 \times 8) + (8 \times 12) = L \times 28\frac{1}{2}$, or $L = 344.5 \div 28.5 = 12$ ft. nearly.

This shows that the second crane should be located over the center of gravity of the right-hand division. In case the casting is too short to prevent both the cranes from being located over it, then a spacer must be used as at B in Fig. 1.

Now consider the actual problem shown in Fig. 1. The spacer A loads the pair of 60-ton cranes at the left equally when the sling is attached to the middle point of the spacer. It is also readily seen from the illustrative examples given above that these two cranes may be unequally loaded if desired by proportioning the lengths of the two ends on each side of the sling on the spacer A.

The total load as stated above is 225 tons, which is an overload of nearly 41 per cent. By proportioning the load on this basis on the two slings the pair of 60-ton cranes will have to carry 170 tons, and the 40-ton crane will have to carry 55 tons. It so happens that the center of gravity of this casting is near its middle. Assuming this to be true and also that the minimum length of the spacer B is 6 ft. in order to reach under the third crane, and that the length of the casting is 12 ft., the location of the left sling for the pair of cranes can be found by the principle of moments in this way:

Taking the pivot at the extreme right-hand end of the spacer B, $170 \times L = 225 \times 12$, or $L = 225 \times 12 \div 170 = 15.88$ ft. Therefore, the distance of the sling for the pair of cranes from the left end of the casting is $18 - 15.88 = 2.12$ ft. As this location is a very convenient one for the sling it is not necessary to increase the length of the spacer B and make another calculation.

Graphite Feeders

SIMPLE FORMS OF GRAPHITE FEEDERS WHICH CAN BE MADE UP WITH ORDINARY FITTINGS. BY JAMES E. NOBLE

NUMEROUS descriptions of homemade scale treating graphite compound feeders for steam boilers have been printed from time to time and the ones described in this article do not differ greatly in principle of operation from those already known to the readers. There are, however, several features in connection with those here shown that to the writer's knowledge have not been touched upon elsewhere. The construction of the feeders described in this article is extremely simple. In some cases not one hole has to be drilled, the device being simply an arrangement of pipe fittings and valves.

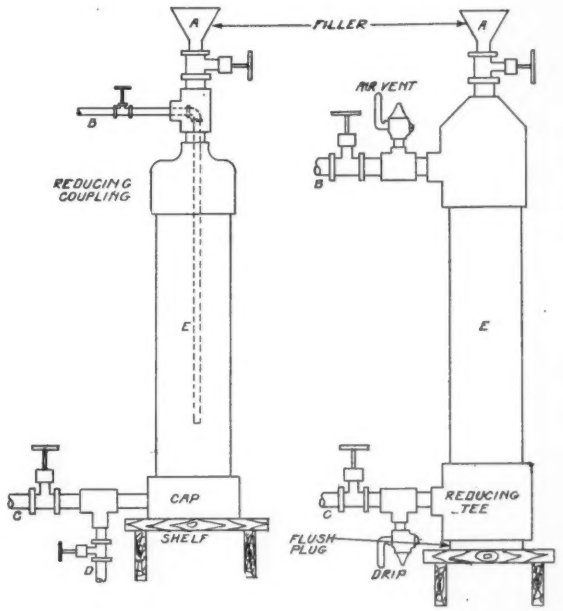
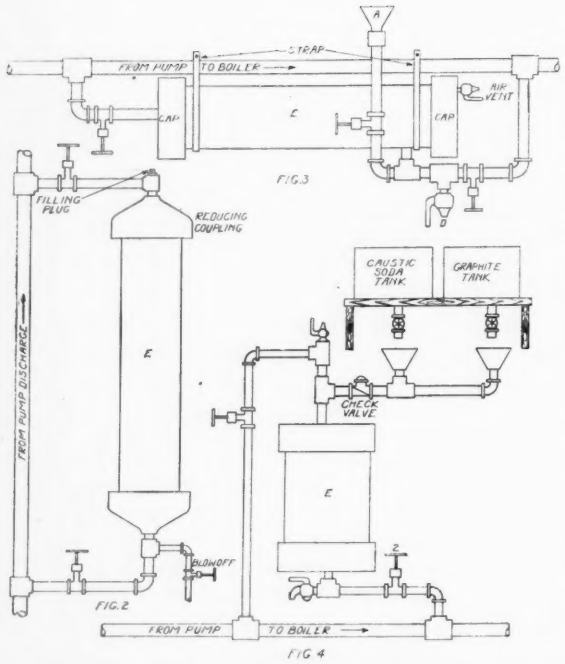


FIG. 1. TWO TYPES OF GRAPHITE FEEDERS FOR USE WITH WATER ONLY

Finely powdered graphite can be fed to boilers through the feed pump benefiting the pump packings as well as the boilers. This is true only when water alone is mixed with the graphite. When the graphite is mixed with soda ash or caustic soda solution, the mixture should not go through the pump, as the soda will decrease the life of the packings.

No known chemical action occurs in the use of graphite; its action is purely mechanical. It is believed that the small particles of graphite work their way into and through the minute cracks in the scale, ultimately coating the surface of the shell and preventing the adherance of new scale and causing the old deposits to fall.



FIGS. 2 AND 3. TWO TYPES OF GRAPHITE FEEDERS FOR USE WITH SODA OR CHEMICALS

FIG. 4. GRAPHITE FEEDER AND METHOD OF INTRODUCING CHEMICALS AND GRAPHITE

It is best to feed graphite directly into the boiler, as this material should be in a vessel where the water is in constant circulation, otherwise it is liable to settle. I have heard of cases where the graphite was thrown into a hot well and later condemned as useless; of course little of the material ever reached the boiler. The time required to loosen up scale depends upon its thickness, hardness, and composition. In some cases it may require 6 or 8 mo. to clear the boiler of scale. After starting the use of any scale removing chemicals or cleaners, the boilers should be opened and cleaned as often as possible to remove the fallen scale, otherwise a bagged sheet may result. If scale that has been removed with graphite, or graphite and chemicals, is examined through a magnifying glass, it will be noted that the side which had been attached to the boiler shell, as well as the shell itself, is covered with graphite specks. In a particular plant having six 100-hp. (so-called) boilers in use, the quantity of the powdered graphite and caustic soda used per day was 1 lb. and 4 lb., respectively. Of course the quantities of ingredients used must be regulated to suit the particular water in use. If too great a quantity of soda of any kind is used, foaming will occur.

In Fig. 1 the chamber E, which in all the designs shown can be made from iron pipe of any desired diameter and length, is first emptied by closing B and C and opening D. After closing D, the chamber is filled with a solution or mixture of powdered graphite and water of about the consistency of thin cream, the valve B which is connected to the pump discharge is slightly opened, and also the valve C which is connected to the pump suction; this allows the mixture to leave the chamber slowly. No caustic soda is used in these two feeders. In the type shown in Figs. 2 and 3 soda and graphite or chemicals can be used, as the compound does not pass through the pump. Figure 4 shows a slightly more elaborate outfit; valves 1 and 2 must be closed while filling the chamber E.

In all these feeders, a glass, showing the amount of compound in the chamber, can be added if desired.

Making Work Fascinating as a Factor in Reduction of Waste*

CONFUSION OF CLASSES OF LIFE HAS RESULTED IN THE BUILDING UP OF INDUSTRY AROUND MISTAKEN IDEAS THAT THE WORKMAN IS AN ANIMAL. BY WALTER N. POLAKOV

EFFORTS TOWARD increasing production by introducing labor-saving automatic machinery has developed two by-effects which have greatly reduced the advantages anticipated: (a) Automatic high-speed machinery, sold at a high price, increases overhead often in excess of reduction in payroll; (b) automatic, semi-automatic, high speed and single purpose machinery of modern industry makes the work of its attendants monotonous because it lacks the stimulating interest furnished by work requiring exercise of the mental faculties. The general consequence of both of these tendencies has been toward increased cost of production rather than towards a reduction of expenses. In times of industrial depression idle expensive equipment greatly increases cost of ownership. The workers, on the other hand, failing to get stimulation and satisfaction from work as mere parts of automatic machinery, demand shorter hours of this drudgery and higher compensation with which they can buy the interest, stimulation and pleasure which they fail to find in the work itself.

The solution to this problem can obviously not be obtained by scrapping existing machinery or putting a ban on further inventions—such a course would be contrary to the nature of mankind. What must be done, however, is the abolishment of industrial monotony and drudgery of work by introducing into it intelligent, self-expressive, creative motives. The problem thus resolves itself into one of making work fascinating as a means of releasing the desire to work.

SHORTCOMINGS OF EARLY ATTEMPTS TOWARD INCREASING PERSONAL EFFICIENCY

THE EARLY attempts to make workers personally more efficient are generally connected with the Taylor system of management. The characteristic features of this system are (a) specialized division of function and (b) detailed time studies of operation. A score of years of trial of this system has clearly demonstrated its inherent, organic shortcomings in many industrial establishments.

Functional foremanship, with brain work divorced from manual work, has made the performance of work

*Abstract of paper delivered before the American Society of Mechanical Engineers, New York, Dec. 5 to 9.

still more automatic and irresponsible. Creative, intelligent work has also been removed from the shops themselves and concentrated in a planning department or general offices, which lacks direct personal touch with workers. Time studies and instruction cards, by standardizing workers' manipulations, have caused the operations to become still more monotonous, repetitive without variations and devoid of stimulative self-expression.

Time studies, motion studies and other means of studying the work are in themselves commendable as steps toward substitution of "guess" and "opinions" by measured facts. Unfortunately, however, all these means lead to standardization and mechanization of manipulations. Once man is lowered to the level of an automaton, the creative element is driven out of his work and subsequent difficulties are impending.

Recognition of these fatal mistakes has prompted industrial engineers to concentrate on the shortcomings of management itself. These efforts have (1) decentralized the detached intelligence of the planning department by establishing manufacturing offices in the shops; (2) reunited the instructing and inspecting functions of foremanships; (3) substituted for time-study clerks the direct interchange of worker's skill and intelligence; and (4) stimulated interest in the work by training and providing instruments for intelligent control of processes; (5) liberated the suppressed creative instincts of workers by providing them with means for observing their own progress, and, finally, (6) devised a charting method permitting the accurate measurement of managerial efficiency separately from the efficiency of workers.

For some time past weariness of spirit and dissatisfaction with brutalizing monotony of work not only has made the workers in this country as well as abroad restless and irritable, but also has moved them to demand short hours and high pay for drudgery, while the quantity and quality of personal output has sometimes decreased in spite of concessions made.

Self-Expression Fundamental in Human Nature

This failure to recognize true human nature and its fundamental natural power constantly and forcibly seeking self-expression is the basic cause of the alarming extent of industrial waste. It is significant that our losses are primarily due to the application of animal standards to human creative activities in industry. The monotonous pursuits, the drab existence, the unimaginative lives of the rank and file of labor make it impossible to tap our creative resources to their full extent. Neither is it possible to produce under such conditions material and spiritual wealth at a full rate without hindrance of conflicts.

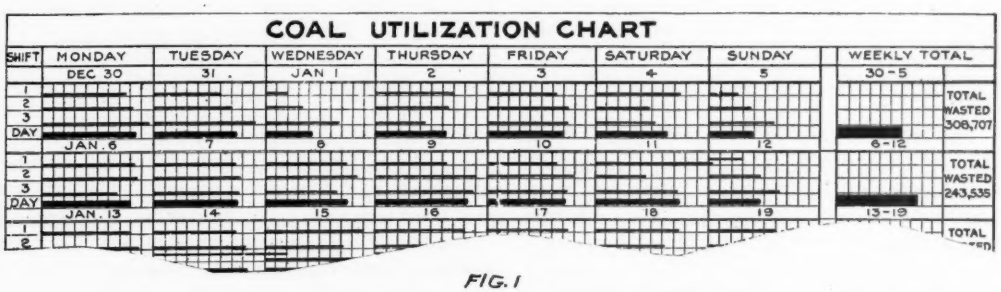


FIG. 1

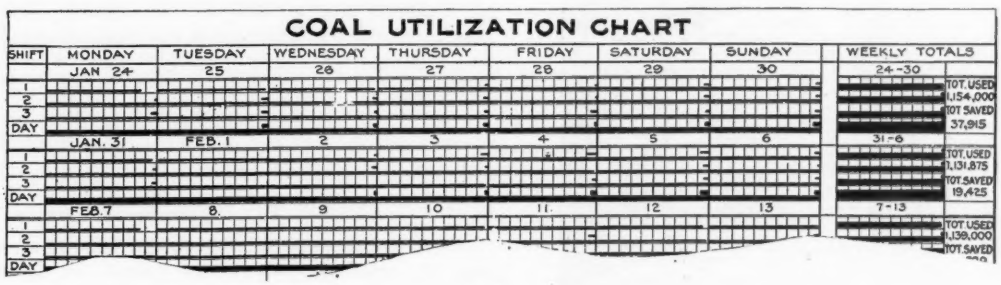


FIG. 2

Based on efficiency obtained by each gang for each day. If efficiency is below 72 per cent the bars on the chart are proportionately short; if efficiency is higher than 72 per cent the bars are doubled up. Note the progress in elimination of waste from January 1919 to January 1921 on chart in Fig. 6.

FIGS. 1 AND 2. COAL-UTILIZATION CHARTS

Studies of industrial fatigue have attracted widespread attention both in this country and abroad. It has been proved by various investigators that a great deal of waste in production is due to unnecessary fatigue, as distinguished from that necessary for performance of work under the most favorable conditions. An even more important finding, however, is that physical fatigue itself is largely traceable to mental and nervous allied factors.

In this connection the elimination of monotony and the provision of mental and emotional stimuli, making work at least in a measure fascinating, is the fundamental requirement for reduction of such industrial wastes as irregular attendance, large labor turnover, irritability of workers, inattentiveness, susceptibility to accidents, poor workmanship, high percentage of spoilage, low individual output, etc.

Initiative vs. Creative Type of Individuals

It would be a mistake, however, to think that repetitive, monotonous operations lack fascination to every-

one. In fact, there are certain individuals who can best express themselves by performing a well-standardized operation. They find a delight in mere mechanical functions least interfering with an independently occupied mind wandering away from the job. This *imitative* type of mind should never be confused with the *creative* type, and the selection of men and women should be practiced along these lines. As to the means of making work fascinating to either type, these are as different as the types themselves.

Instinctively feeling that at the bottom of many labor troubles the monotony of animal-like work is to be found, a large number of manufacturing concerns have adopted a policy of diverting the attention of workers from the shortcomings of working conditions to the refreshening activities of "welfare" work. While a measure of success has been recorded in several instances, the movement is obviously directed along the wrong course. The material effect of this attempt to administer "spiritual cocaine" to help endure a painful operation was sometimes temporarily expedient, yet the moral was decidedly degrading because of the silent admission that work is a curse, that no attention should be fixed on production, that there is no interest or satisfaction to be found in industry and that special award and entertainment is to be looked for outside of one's

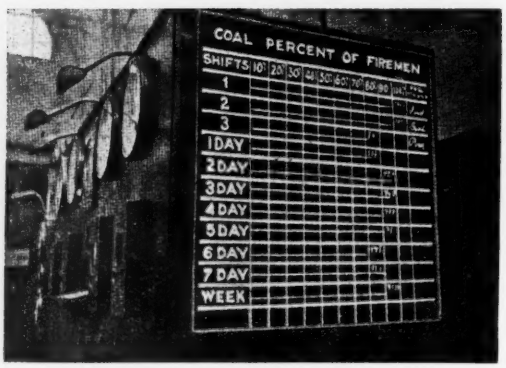


FIG. 3. FUEL UTILIZATION CHART BOARD PLACED IN BOILER ROOM AT THE REQUEST OF THE MEN

vocation. Such a practice eventually ruins the spirit of industry and breeds further demoralization.

Incentives to higher production, so far as workers are concerned, have been offered, both financial and non-financial. As a means for securing the interest of workers in the work itself, these incentive payments are obviously unfit, for they merely create interest in securing a larger pay. The work itself, in so far as it is spurred and speeded up by anticipation of a monetary premium, becomes still less attractive.

Non-Financial Incentives Stimulate Thinking

Non-financial incentives, on the other hand, have demonstrated the value of an environment which stimulates thinking. By having opportunity constantly to increase their knowledge of the underlying natural laws of the process, the workers are able to realize the joy which comes from a conscious mastery of their part in any process. The creative activity is the final aim of human beings, yet to preserve life we must not only provide the material requisites of food, clothing and shelter, but must meet also the higher demands of human life commensurately with the degree of culture and service rendered. Greater service rendered is both conditioned and followed by greater material reward.

A method of compensation of this character stimulates the development and exercise of creative power, encourages elimination of waste and does not suppress the desire to serve. In seeking these aims the fascination is readily found, while the interest in improvements and accomplishments is not pushed to the background by financial uncertainties or worries.

Another notable attempt to combat the evils arising from the lack of interest provided by mechanized work may be observed in the hopes aroused by certain claims that a careful selection of workers to fit the work will eliminate dissatisfaction created by the poor fitting of men to jobs. These hopes wane as rapidly as they spring into prominence because the selection of men for jobs is an error of lowering a dimension. The correct course would be to fit the jobs to the men; in other words, to elevate the work to human dimensions, requiring not mere physical or animal power but an exercise of creative, intelligent faculties as well. The first step along this road is training the worker, as opposed to securing unambitious, discouraged ones of low intelligence and further degrading them by assigning them to perform the lower functions of beasts of burden.

The next step advocated is to organize the work so that the worker's intelligence and his creative or imitative instincts will be brought into play. This requires (1) analysis of jobs and processes to bring out the interrelation of causes and effects and (2) the education of operators in conscious control of these forces and relations so that they can at will influence the results.

Making the Work Interesting

In the author's experience in promoting and increasing industrial efficiency, he has found that the most fundamental, most successful and most enduring way to do it is in the elevation of man to his true dignity as an intelligent, creative agent. We rearrange his work so that it requires the exercise of his mental and spiritual faculties and capacities. We make his job interesting, sometimes exciting, often fascinating. This way he liberates his creative capacity, give him a measure of satisfaction in what he is doing and only then are we able to reduce that waste which constitutes our sad national characteristic. To be specific, the monotonous physical labor of a fireman is readily transfigured by special training into a fascinating game based on the exact sciences of physics and chemistry, requiring an exercise of mental capacities. Watching and interpreting a simple array of instruments provides men with interest, which is augmented as they intelligently control a process and watch the results attained.

Charting the progress made in elimination of waste of material provides further source of satisfaction in observing one's own improvement in the mastery of processes through the acquisition of knowledge and skill. These charts (Figs. 1 and 2) are plotted on the basis of what is possible of accomplishment with a proper exercise of intelligence, knowledge, and skill, and the short bars indicate the falling short of possibility. Sometimes it is found that a playful spirit of friendly

competition or just pride in self-improvement and accomplishment prompts men to draw similar records on the fronts of their boilers or elsewhere in the room (Fig. 3). When a man finds himself thinking about his job it loses its monotony. Moreover, the amount of physical labor is reduced in some inverse proportion to the intelligence applied.

Similar organization of jobs and corresponding transformation of workers' attitude have been successfully tried in a variety of establishments—in the glass industry, pulp and paper mills, foundries, power plants, etc.—and the further application of these principles awaits the progressive co-operation of manufacturers and industrial leaders.

Federated Engineering Societies

FEDERATED ENGINEERING SOCIETIES ANNUAL MEETING. NEW OFFICERS. ADDRESS BY MR. HOOVER.

ROUNDING out a year of improved organization, substantial accomplishment and strengthened purpose, the American Engineering Council of the Federated American Engineering Societies held its annual meeting at the Cosmos Club, Washington, Jan. 5 and 6, Dean Mortimer E. Cooley of the University of Michigan, president of the Council, presiding. Officers were chosen, the work of the past year reviewed and discussed, action taken on important matters of public and technical service, new financial arrangements put into effect, committees named, new policies sanctioned and old ones reshaped, and a broad and definite program outlined for the next twelve months. A leading event of the meeting was a dinner in honor of Herbert Hoover, who, addressing the members of the Council and their guests at the University Club, praised the work of the Committee on Elimination of Waste in Industry as a great and lasting public service, pointed the way for new engineering effort in the public interest and expressed renewed devotion to the ideals of the Council. Resolutions of appreciation of the service of the new Secretary of Commerce were presented to Mr. Hoover.

Mr. Hoover said in part:

"Elimination of waste, now causing billions of loss annually to the American people, is the most fundamental of all problems with which the nation must deal. Great distortion between the cost of commodities to the consumer and the producer exists and unless this distortion, which is bearing heavily on the consumer, can be overcome, the American farmer will be reduced to the status of a European peasant. The way to a solution for the country is in the direction pointed by the findings, recently completed, of the American Engineering Council's Committee on the Elimination of Waste in Industry which recently completed a national investigation of industrial waste. As a result of the investigation of the engineers there has been greatly increased consideration of the fundamental questions of industrial waste throughout the country and the standards of living of the American people are being inquired into as never before."

Mr. Hoover eulogized the American Engineering Council as a new and powerful force in the life of the nation, saying that in a unique way it has won the confidence of the republic as an agency of national and state co-operation which was without the slightest selfish motive and through the efforts of which no man could profit save as a citizen in common with all other citizens. The organization of the council marked the evolution of 200,000 engineers of America into public affairs as a mighty instrument possessing rare knowledge of both material and intangible values.

The engineer has come to be accepted by the American people as wholly single-minded in his devotion to the highest social economic and political ideals of the state. Mr. Hoover said he had felt that it was the duty of the government to take up some of the problems outlined by the American Engineering Council and the Department of Commerce had established agencies to this purpose.

Taking 100 as the basis of the cost in 1913 to the producer and consumer, today the cost to the producer can be regarded as 100 while the cost to the consumer has risen to 150 and even 170. Only through the elimination of waste can the existing inequalities be wiped out. Taxation, state and federal, has greatly increased the distortion. These conditions are not now due to swollen profits, but to the existence of avoidable waste. Economies of manufacture, transportation, distribution and other agencies must be sought. Idle men is one of the greatest causes of waste, because lost labor, once over the dam, is lost forever.

One of the biggest problems confronting the country, Mr. Hoover thought, was that of electrification, suggesting that the engineers tackle this problem in the form of a waste survey. Such a survey, he said, afforded at this time the great possibilities in the direction of effective leadership in the elimination of waste. He asked the engineers to take up the problem in a larger view of electrification. The proposed super-power area along the Atlantic seaboard in the region between Boston and Washington is the starting point, for prodigious development in consolidating the electrical powers of the country along national lines which would affect every village and hamlet, combine into super-power stations hundreds of thousands of minor electrical plants with millions of horsepower and result in tremendous savings to industry.

Mr. Hoover predicted that in this and other fields the engineer was destined to be of great service to the nation. Engineers he styled "the world's greatest realists". The service to the country during the first year of its organization has been a small measure of what the American Engineering Council is bound to accomplish.

Dr. B. Stefanek, minister from the Republic of Czecho-Slovakia, also spoke, paying a glowing tribute to the American engineers for their investigation of industrial waste, which report, he said, had been translated by his government and would be widely circulated in Czecho-Slovakia.

Dean Cooley, in opening the sessions, declared his

confidence in the future of the Council and outlined generally his plans for more effective organization to be carried out in co-operation with the executive secretary, L. W. Wallace. President Cooley will soon start on a tour of the South and Southwest, and one of the biggest meetings he is to address will be in St. Louis, Jan. 18. Mr. Wallace has also mapped out a traveling schedule to further the work of organization.

Encouraging reports over the outlook for additions to membership were reported to the Council. The Engineers Club of Columbus, Ohio, was admitted to membership. "It is gratifying to note," said the report of the executive secretary, "that with one possible exception no society will withdraw at the moment from the Federation. There are more than twenty active prospective members." Mr. Wallace urged an active and aggressive campaign to secure a much larger membership, stating "that it is evident that the Federation cannot reach the maximum possible attainment until virtually every engineering society is a member."

The secretary's report showed that on Jan. 1, 1921, the membership of the society was composed of six national and fourteen state and local societies, a total of 20. On Dec. 31, 1921, there were eight national and twenty state and local societies, a gain of eight member societies. Amendment to the constitution was adopted making it possible for the executive board to fix the annual dues, but not to exceed the amounts fixed by the former article. Also the bylaws were so amended that the board can determine at the beginning of the year the number of board meetings to be held, their date and location. After much discussion as to the desirability and the effects of laws for registration and licensing of professional engineers, the matter was referred to a special committee to investigate the matter and report its findings.

Balloting for officers resulted in the re-election as vice-president of Dexter S. Kimball, dean of the College of Engineering, Cornell University, and J. Parke Channing of New York. W. W. Varney of New York was again chosen treasurer. L. W. Wallace was re-elected executive secretary by unanimous action of the executive board.

Endorsement was given to the bills before Congress providing for completion of the topographic mapping of the country, for rehabilitation of the Patent office and for gathering of government engineering work into one department.

The Council voted to co-operate in the movement to prepare for cyclical industrial depressions and unemployment by resort to public works projects. On this subject the Council received a proposal from Mr. Hoover and it was decided to open conferences with him to ascertain in what way the Council could best provide effective aid.

New representatives on the Council were announced as follows: American Society of Mechanical Engineers, Francis Blossom, Charles A. Booth, Gano Dunn, H. H. Esselstyn, W. S. Lee, I. E. Moultrop, John H. Stevens, A. E. Walden; Society of Industrial Engineers, Prof. Joseph W. Roe; American Institute of Mining and Metallurgical Engineers, C. H. MacDowell; Louisiana Engineering Society, Prof. Donald Derickson; Iowa Engineering Society, Lloyd B. Canfield; Duluth Engineers Club, W. H. Hoyt; Milwaukee Engineering Society, Albert Blatz, Jr.

The executive board of the Council for 1922 is made up as follows: H. E. Howe, Washington, American Institute of Chemical Engineers; Prof. C. F. Scott of Yale, L. B. Stilwell and Calvert Townley of New York, J. H. Finney of Washington, William McClellan of Philadelphia and L. F. Morehouse of New York, representing the American Institute of Electrical Engineers; J. Parke Channing and A. S. Dwight of New York, Charles H. MacDowell of Chicago and Philip N. Moore of St. Louis, the American Institute of Mining and Metallurgical Engineers; L. P. Alford of New York, E. S. Carman of Cleveland, Dean D. S. Kimball of Cornell, Prof. A. M. Greene of Troy, Dean Perley F. Walker of Kansas, W. S. Lee of New York, Dean M. E. Cooley of Michigan, American Society of Mechanical Engineers; Prof. Joseph W. Roe of New York Society of Industrial Engineers; Morris L. Cooke, Philadelphia, Taylor Society; W. E. Rolfe, Associated Engineering Societies of St. Louis, W. W. Verney, Baltimore.

Regional directors chosen for 1922 are: District No. 1, W. B. Powell, Buffalo; District No. 2, Gardner S. Williams, Ann Arbor, Mich.; District No. 4, W. J. Fisher, York, Pa.; District No. 5, Paul Wright, Birmingham, Ala.; District No. 6, L. B. Smith, Topeka, Kan.; District No. 7, O. H. Koch, Dallas, Tex.

To assist in the conduct of engineering research and to extend and strengthen the field of its graduate work in engineering, the University of Illinois maintains fourteen Research Graduate Assistants in the Engineering Experiment Station. Two other such assistantships have been established under the patronage of the Illinois Gas Association. These assistantships, for each of which there is an annual stipend of $600 and freedom from all fees except the matriculation and diploma fees, are open to graduates of approved American and foreign universities and technical schools who are prepared to undertake graduate study in technical subjects.

An appointment to the position of Research Graduate Assistant is made and must be accepted for two consecutive collegiate years, at the expiration of which period, if all requirements have been met, the degree of Master of Science will be conferred. Nominations to these positions are made from applications received by the Director of the Station each year not later than the first day of March. Nominations are based upon the character, scholastic attainments, and promise of success in the principal line of study or research to which the candidate proposes to devote himself. Preference is given those applicants who have had some practical engineering experience following the completion of their undergraduate work. Appointments are made in the spring, and they become effective the first day of the following September.

Research work and graduate study may be undertaken in architecture, architectural engineering, ceramic engineering, chemistry, civil engineering, electrical engineering, mechanical engineering, mining engineering, municipal and sanitary engineering, physics, railway engineering, and theoretical and applied mechanics. Additional information may be obtained by addressing The Director, Engineering Experiment Station, University of Illinois, Urbana, Ill.

Decreasing Temperature of Circulating Oil

In a large western sugar refinery, where all the electric power that is used in the plant is generated at the plant by means of steam turbines, several unique installations have been made with the idea in mind of obtaining the maximum efficiency possible from the circulating turbine oil.

At this plant, a more or less constant load of approximately 3000 kw. is carried on two of the three 1500-kw. non-condensing turbo-generators. For purposes of lubrication about 6 or 7 bbl. of turbine oil is kept circulating through the bearings of these two turbines and back down through an oil filter of a capacity of 50 to 60 gal. per hr. A part of this returning oil is filtered and the remainder is bypassed to the storage tank of the filter, from which it is again drawn out and put into circulation.

When the turbines were first installed and put into operation, trouble was experienced from high oil temperature. This temperature would at times rise to 180 deg. F., which of course is high for both oil and bearings, the former tending to break down the oil, and the latter becoming heated and covered with a black deposit from the oil. In addition to this, the oil seemed to contain an acid which roughened bearings and rods.

Upon investigation, it was found that the trouble experienced was due to several causes.

1. The oil was highly aerated, this aeration tending to break down the oil and form acids. The cause of the aeration was twofold:

(a) The return oil from turbines to oil filter was allowed to dump directly from the return pipe into the filter tanks. The oil would thus carry in a certain amount of air as the steam entered the oil body. This fault was corrected by the installation of fan-shaped receiving plates onto which the oil is now delivered and forms a flat fan-shaped film which is delivered into the oil body without impact and consequently does not entrain air into the oil body.

(b) Secondly, the other aerating agency proved to be the small centrifugal pump, that received the oil from the oil receiver and returned it to the turbines. This pump, which was a little too large for the service, tended to churn and aerate the oil. To remedy this, the centrifugal pump was removed and a small duplex steam pump substituted.

When these two things had been accomplished, the aeration apparently ceased and the temperature of the oil dropped to about 150 deg. F.

This being still too high, an auxiliary cooling tank was installed as shown in the sketch. The cooling coil consisted of 200 ft. of 2-in. copper coil, which was introduced between the outlet from the oil filter and the receiver. This copper coil was immersed in a round redwood tank 4 ft. high and 4 ft. in diameter. Through this tank a stream of cold sea water is kept circulating from the refinery salt water system. By the introduction of this cooling coil, the circulating oil temperature was reduced to 125 deg. F. at the turbine bearings, which is quite reasonable for this type of machine.

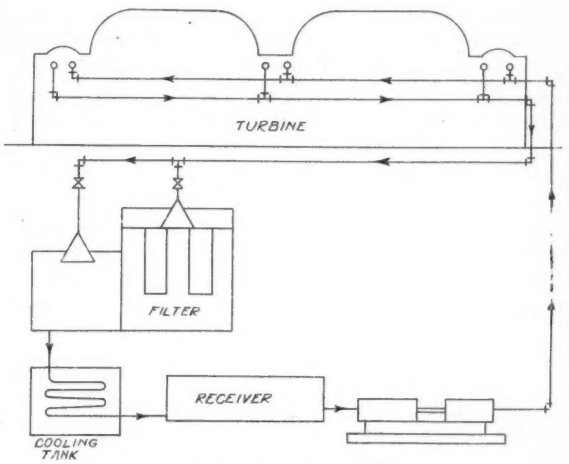


DIAGRAM OF OIL PIPING

Claude Brown.

Engine Breakdown

The following account of an engine accident which occurred in a plant at Woodland, Conn., on December 22 may be of interest to some of the readers:

The engine was a 26 by 48-in. single eccentric Corlis doing service in a paper mill. At 7:30 p. m. on the above mentioned date the piston rod broke off in the unit on the crosshead. The piston rod and piston weighed about 650 lb. and with full steam pressure behind it was capable of doing considerable damage when suddenly let loose. It mashed out the head and went clear across the engine room, cutting off a 4-in. steam main in its path. The engine room, of course, became filled with steam immediately and a few moments later all the sprinklers on the fire protection system opened up.

The head fireman had just left the engine and was not more than 8 ft. away when the accident occurred. It was impossible to go back to close the throttle so he hurried to the boiler room to shut off the main header. While he was attending to this I shut off the water which was already about a foot deep in the engine room, and so hot that I could not wade in it.

The flywheel on this engine is 16 ft. in diameter and weighs about 40 T. We used a Hodge rope drive and found that the rope shrunk considerably due to the action of the hot water.

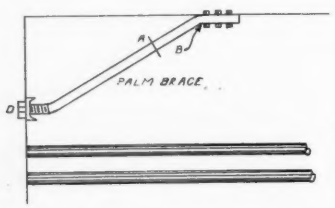
Repair work was started at once. The manufacturers made good time in getting out the old piston, reboring the cylinder and putting in a new rod. The head was extra heavy and we had a difficult job when it came to digging out the 16 bolts which had been stripped or broken off. In four days, however, the work was completed and we had the machine running as good as ever. The cause of the accident was due to a flaw in the piston rod.

JOSEPH ENGLISH.

Hammer Test Inspection

INSPECTORS rarely give a boiler a thorough inspection without the use of a hammer, and there can be no argument against the fact that it is most useful, but it certainly takes a wonderful ear that can detect small cracks by the tapping of braces; but where the crack is large, of course it will affect the sound and the hammer test should be ignored.

I recently had these statements proven to me while going through my boilers when first taking the plant. The boilers had been regularly inspected by a well-known boiler insurance company, who always used the hammer test. But while I do not discard the hammer,



BOILER BRACE SHOWING LOCATION OF CRACK

I insist on having a 60-w. electric light which I hold to parts being inspected, and, and in this way I have found three palm braces each having from one to three cracks invariably at B, in the accompanying sketch. On finding these, I immediately called the inspector who had previously been through them. He came out and after examining them with a magnifying glass stated that they would have to be renewed; but in one case he stated that he didn't care if it was not renewed, because the channel iron across the head would hold the strain, but when I told him that the brace broke because it was under a strain, he frankly stated that it should be replaced.

If you ever tried to take off the nut D on a brace that's been in 26 yr., you won't forget it. No wrench could move it; after using a blowtorch, it would not move; so two ¼-in. channels were cut through one side of the nut clear to the threads, and by much hammering it finally started. The rivet heads were cut off at the top of the boiler and brace taken out and a new piece 20 in. long was welded on at A, because the brace looked to be O. K. towards the front of boiler. This job cost $70 per brace.

I claim that the use of a strong light in looking over these boilers is of most importance to find hidden cracks. It is keeping the inspectors guessing what has caused these palm braces to crack all in the same place at B and all the same kind of brace. The through braces do not show any cracks that I can find. Since this case there are two inspectors on the job at every inspection.

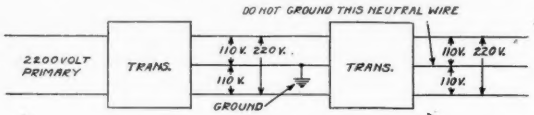
Use plenty of light in addition to the hammer, for I believe that numerous cracks in braces are passed over by inspectors because candles are used instead of an electric light extension lamp.

A. C. WALDRON.

Light Wiring for Power Plants and Substations

IN READING the article, "Hazards of Extension Cords," by R. K. Long, page 872, September 1 number of Power Plant Engineering, I was reminded of a circumstance occurring in our plant sometime ago.

A boilermaker working in a drum got tangled up in an extension cord and received an almost fatal shock. This caused the department heads to devise a remedy to overcome a condition allowing such an accident. One of them conceived the idea of a transformer wound one to one, primary winding being 220-110 and the secondary being 220-110, tying two middle leads to the



WIRING DIAGRAM FOR LIGHTS

regular neutral for the primary side, and on the secondary side using the regular hook up with the exception of not grounding the neutral wire. This transformer being tied in on the line in this way gives us a safe arrangement, permitting no possibility of receiving a shock as there is no voltage to ground.

The same results can be had on any regular lighting transformer, provided the neutral wire is not grounded. This, however, leaves a condition which should not exist; for, should the primary winding break down, there might be a possible chance of not detecting it. This condition could not exist in this state (California) as there is a law compelling us to ground one of the secondary leads.

This idea gave us the basis for ordering an especially wound transformer, primary 220-110, secondary 220-110.

JOHN F. WINN.

When Looking for Trouble

MANY OF US, when looking for trouble in machinery, too often imagine that we will surely find something "big," or there would not exist such a mean case of trouble.

I recall an incident where two "old heads" were working on a machine that had an intermittent defect.

"Well, Joe, I've gone all over her and I'll swear I don't see a thing wrong."

"All right, Tom, let's start her up."

She was started and worked all right for a few revolutions; then, as Joe said, she seemed to develop a hop, skip and jump attitude. A few cuss words were passed and the men held a consultation while they examined the various wedges, cogs, etc.

Standing alongside, watching every maneuver, was a rosy-cheeked young man who seemed more than curiously interested. He started to say something, but hesitated.

Seeing his quandary, I said: "Kinder mulish, eh?"

"Well, I'm not sure, but if I thought the gentlemen would not object, I believe I could help."

"I can assure you there will be no objections," and calling Tom, I told him the young man had an idea, and before I could qualify my remark, Tom sallied forth:

"Boy, the world is run on ideas. If you've got an idea that'll run this damn machine, shoot."

Though a little abashed, the young man took the oil-can and devoted his attention to where there was a slipping clutch gear.

At each revolution the clutch was supposed to make and break contact with its mesh.

After feeling of the parts, I saw that he was complacent; his next and only move was to oil the clutch rods and a back slide.

"Try her now, please."

The machine was tried and worked like a charm.

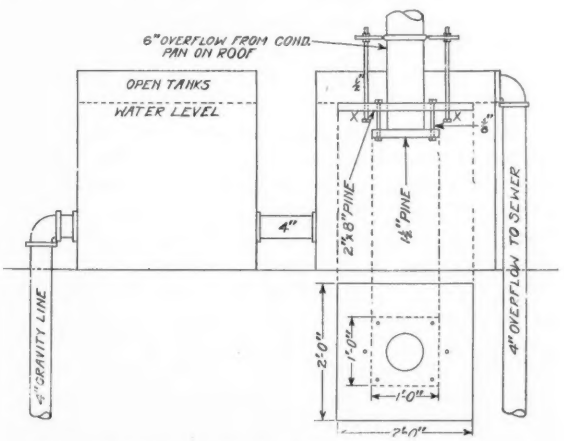
Joe grinned and looking intently at the young man said:

"Well, you put one over on us, how did you guess it?"

"Well, I saw that you examined carefully every bolt, nut and pinion, but you seemed to pass over the clutch as though there could not be trouble within that chamber, and every time she went wild I heard a peculiar noise that I figured could not come from any other place, and besides it had that squeak which means, give me oil." J. B. DILLON.

Preventing Splashing From Overflow Tank

USING the water that flows over our ammonia condenser on the roof throughout the factory for general use by gravity system, we were troubled in warm



WOODEN FLOATS ARRANGED TO PREVENT SPLASHING

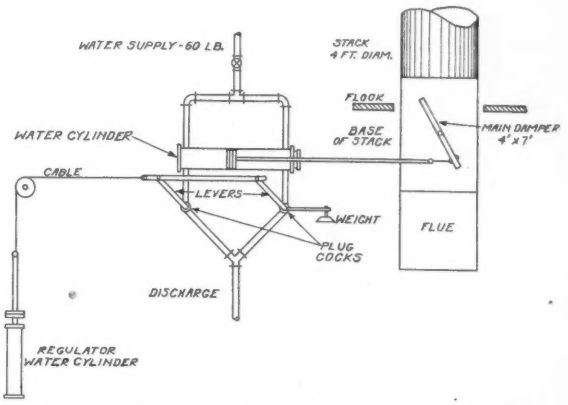
weather when our refrigeration units were working to capacity, by constant splashing and overflow at receiving tanks which were on the top floor of our factory.

The sketch shows how we overcame this. We made a pine float to slip over the 6-in. pipe coming from the condenser large enough so that its buoyancy would be enough to counteract the fall we had from the roof, this float being fastened with bolts to a smaller float which acted as a valve disc, using the face of the overflow pipe as a seat. As you can see by the sketch, there was enough play left in suspension bolts marked X so that when the water in the tanks dropped, that float dropped at the same time from the face of the pipe, allowing a pretty good level to be maintained at all times. As the level rises, the action of the large float brings the small one up against the face of the pipe, acting as a cushion. This has done away with all splashing and overflow which occurred heretofore.

WALTER D. SMITH.

Installing Damper Regulator in Close Quarters

MANY ENGINEERS will bear me out in the statement that if in making alterations in buildings, due to blundering design, or otherwise, any sacrifice has to be made, it is always in the operating plant; and no matter how crippled the conditions which result from the sacrifice, the plant-owners expect the same degree of efficiency as they would from an ideally designed equipment.



DAMPER REGULATAOR ARRANGED FOR SPECIAL LOCATION

I have in mind a large building on the lower West Side, in New York. Foundations were laid for three 300-hp. water-tube boilers. Just before they were installed, somebody discovered that there would not be room in front to do any retubing, so the boilers were moved back several feet, crowding the 4-ft. flue nearly against the party wall in the back, and necessitating the cutting of openings in the flue, in order to enable a person to get through the manholes of the boiler drums.

The individual dampers were inaccessible for anything but hand regulation; consequently, the fireman had to make many trips to the rear of the boilers during a shift.

A Locke regulator was purchased, but had never been installed, as the big steel damper, in the base of the stack, was considered too heavy to be operated by it.

From material on hand, a device was made, as illustrated. A hole was cut through the stack. An eyebolt was attached to the damper, with a link to connect with a plunger-rod working in a cylinder, made of 3-in. pipe strapped to the boiler wall. Well water, at 60 lb. pres-

sure, from the roof-tank, was supplied constantly to both ends of the cylinder. Discharge pipes led from each end of the cylinder, to plug cocks operated by levers connected by cable to the Locke regulator, and with a weight, to move the levers in the opposite direction, so that when one cock was open, the other was closed. The water pressure on both sides of the plunger kept the damper balanced. A slight movement of the Locke regulator allowed the water to escape from one end of the cylinder, when the pressure in the other end would cause the damper to move the proper amount to control the steam pressure.

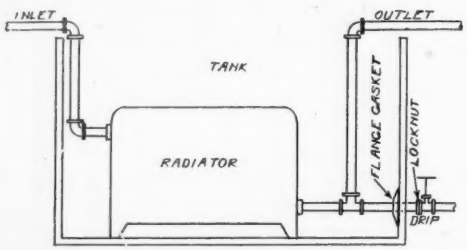
After several experiments, and some "valve setting" of the cocks, the device was made to work satisfactorily, maintaining the steam variation to one pound, and at a cost of about one barrel of water a day, the water costing only the pumping.

M. M. Brown.

Utilizing Exhaust From Feed Pump

In a small power plant the exhaust steam from the feed pump was wasted although the supply of hot water was always less than what was required, so live steam was used to increase the quantity. The engineer received permission to rig up the outfit shown.

Inside of a large wood tank was set an old radiator which had been discarded and replaced by a modern one. To this radiator was connected the exhaust from the pump as shown. The back pressure formed was only about 2 lb. and practically all the steam was condensed. The water was drawn from the tank and carried to the live steam heater, therefore it never got very hot, and the low temperature of the water resulted in extracting practically all the heat out of the exhaust steam. The pump exhaust was, or had been, the only wasted steam, as no steam engine was used. As none of the exhaust came in contact with the water, the tank water was not contaminated by oil.



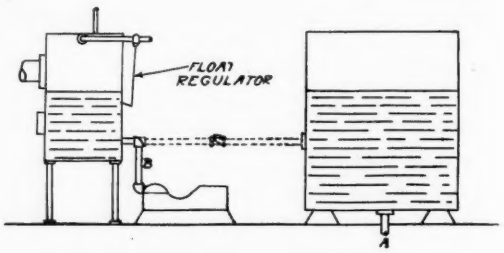
RADIATOR IN SUPPLY TANK HEATED BY EXHAUST FROM BOILER FEED PUMP

James E. Noble.

Heating Dye House Water

On taking charge of a small textile power plant, the writer found in service an open heater for handling the boiler feed and an old closed heater for heating the water for the industrial purposes. This closed heater was about played out and it was the intention to purchase a new one, when it was suggested that we endeavor to eliminate this purchase by putting this load on the boiler feed water heater which seemed large enough to carry it, and since no evidence of oil was found in the boiler feed taken from the heater. The change was made, but it was found that while the heater was large enough to heat the water required if it was drawn out at a fairly constant rate, there was not sufficient hot water storage in it to take care of some of the momentary loads.

We solved this problem by making use of the old overhead tank used with the former system. The heater was raised, and then the tank was installed on the floor, adjacent to the heater, and connected across with a generous size connection into the hot water space. This virtually increased the hot water storage in the heater to provide for the peak loads, the dye house water being drawn off at A and the feed for the boilers at B. A check valve was placed in the hot water equalizing connection so that any reserve built up in the tank would not flow back to the heater. The float and regulating valve in the heater maintained a fairly constant level in both reservoirs. Since both units were under atmospheric pressure, the flow of water through the equalizing pipe was free. This kink saved the expense of investing in a new closed heater or the purchase of a larger type of apparatus.



STORAGE TANK USED IN CONNECTION WITH FEED WATER HEATER

M. A. Saller.

Turning Down Commutators

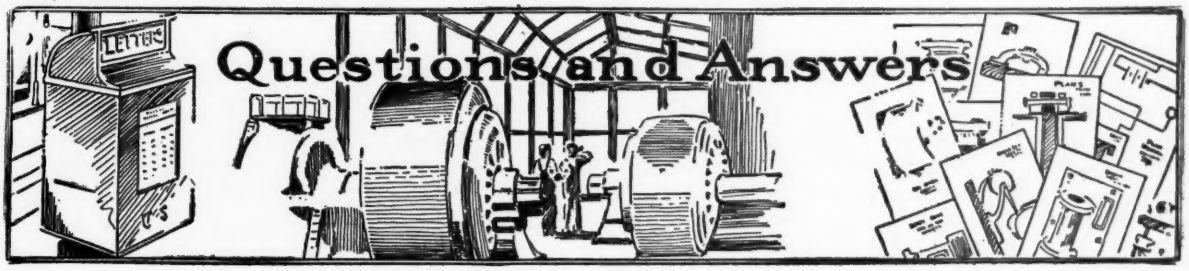
In an article on turning down commutators, by W. B. DeMuth, he speaks of the tool digging in and advises that the edge of the cutting tool should point downward.

Now, in turning a commutator the tool should be narrow at the end, the cutting point, and the edge which does the cutting should be about the center or a trifle below. Should the cutting edge be above the center the tool is liable to dig in and springing the tool post downward dig in still more; whereas, if the tool is below the center, the spring will cause the cutting edge to pull away from the work. Copper is more troublesome to turn than steel, cast iron or brass, and a pointed tool, fine feed and high speed, is the proper combination. One of the tricks of running a lathe is to determine the proper height for the cutting edge of the tool.

One can have the same hard luck with a tool pointing downward and this is not the proper way to use a tool, as the thrust and strain on the tool tends to raise the "slide" or carriage of the lathe.

The writer operated various lathes for many years and great care was required in handling some of them due to the lost motion.

Tom Jones.



Engine Design

How should these examination questions be answered?

1. How does a Corliss engine act when overloaded?
2. Why are some Corliss engines equipped with double eccentrics?
3. What are the advantages of compounding?
4. Would there not be more condensation in two cylinders than in one?
5. How is the ratio of expansion in an engine determined?
6. How is the correct receiver pressure in a compound engine determined?

A. S. M.

Answers

When a single eccentric Corliss engine is overloaded, the cutoff increases to a point where the latch ceases to function, which means that the cutoff is not sharp and that wiredrawing results. When this occurs the steam valve remains open until the eccentric has reached the end of the stroke and returned to a point 180 deg. behind the point of admission, before it closes. This brings cutoff at or near the end of the stroke, and it may easily be beyond the point of release of the exhaust valve. In this case steam will blow directly through the engine cylinder without doing any work whatsoever, which means an enormous loss.

2. Corliss engines are equipped with double eccentrics to enable them to operate under a long range of cutoff. With double eccentric the cutoff may be as late as five-eighths or three-fourths of a stroke. Cutoff at this point is not as economical as at an earlier point because of the fact that the expansion is not as complete. The terminal pressure is high and there is a considerable drop between that and the exhaust pressure, which means, of course, a loss in efficiency.

3. Some of the advantages of compounding are that it permits a long range of expansion; decreases cylinder condensation, due to smaller temperature ranges in each cylinder; decreases clearance and leakage; decreases steam consumption; and equalizes the crank effort. On the other hand, some of the disadvantages are: Increased first cost, increased complexity, increased wear and tear, and increased radiation losses.

The ratio of expansion in an engine is the ratio of the volume of the steam at final release to that at the high pressure cutoff. Commercially it is taken as the cylinder ratio divided by the high pressure cutoff.

The receiver pressure in a cross compound engine may be determined from the equation:

$$P_2 = P_1 \div \sqrt[2]{(P_1 \div P_4)} \times \sqrt[3]{[\sqrt[2]{(P_1 \div P_4)} \div \sqrt[2]{(P_1 \div P_3)}]}$$

where P_1 is the initial pressure, P_2 is the receiver pressure, P_3 is the back pressure, and P_4 is an empirical pressure which may be taken at from 3 to 6 lb.

Pump Becomes Air Bound

Referring to H. W. T's question on page 1221 of the Dec. 15 issue, we have had somewhat the same experience and I would therefore like to make a few comments.

At first sight there seems to be a leak in the intake line. Merely a small leak would be effective in breaking the suction in a line of this size. Poor threads, a cracked elbow or a pitted pipe would be sufficient to cause this trouble. If this line has a good foot valve, as it should have, it may be tested for leaks when the pump is stopped. The intake pipe has two ells and part of the line is horizontal, hence there is a chance for air to accumulate, until there is enough to break the vacuum. A vacuum gage placed in the suction line close to the pump would indicate such a condition. It would be well to set the intake line on an incline to eliminate the possibility of air pockets.

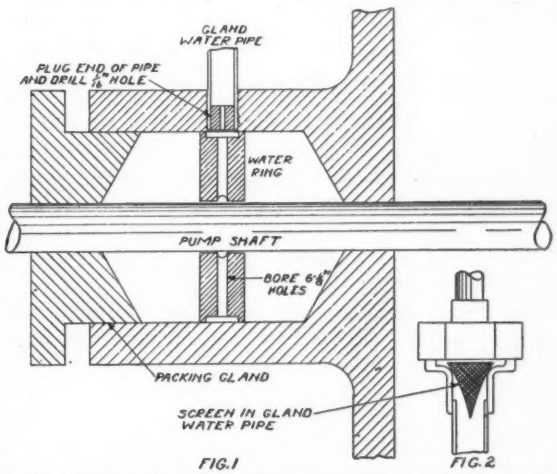


FIG. 1. SECTION OF GLAND SHOWING LANTERN AND PLUG IN WATER CONNECTION

FIG. 2. SMALL MESH SCREEN IN UNION ON GLAND WATER LINE

I am not in favor of using an 8-in. suction line, the 6-in. is sufficiently large for the purpose. With an 8-in. line, the velocity is exceedingly low and the smallest leak will break the flow.

Pumping from a creek, it is possible that some foreign material has been sucked into the pump and is clogging the impellor vanes. Protection may be afforded by covering the intake with a screen of such mesh that nothing will pass that will lodge in the pump.

The trouble with the packing burning out on the

motor end may be caused by a sprung shaft or a worn bearing or by the fact that the gland washer is not reaching the shaft. Often no water ring is used and as the packing gets old, more is added, the whole becoming so firmly wedged in that water will not penetrate. The function of the water seal is to lubricate and cool the shaft so that the packing should not be too tight. I would not advise a rubber packing in this gland, as well graphited tallow treated hemp would better serve the purpose. The gland nuts should not be turned up tight. The use of a short wrench should be all that is necessary.

If there is no water ring in the gland, one can be made of babbit as shown in Fig. 1. When the gland is packed, make sure that the gland water line is opposite the groove. The water for the gland should be taken from the first stage through a pipe not less than ⅜-in. diameter. To reduce the amount of water in circulation, the end may be plugged as shown in Fig. 1 and drilled with a 1/16-in. hole which will give plenty of gland water to a 2½-in. shaft. It will be well also to provide a small mesh wire screen in one of the unions as shown in Fig. 2, so as to remove any foreign particles that may be present in the water.

CHAS. LABBE.

Massachusetts Second-Class Engineer's Examination Questions

WHAT WOULD you do if you had a Spencer damper regulator that closed in good order, but would not open until the pressure had dropped 15 lb.?

A. The trouble is probably due to the fact that the pilot valve is set too high; lowering it will remedy the difficulty.

2. Why does the front head on a horizontal return tubular boiler of the overhanging type flange out instead of in?

A. This question is sometimes answered by saying that the head is flanged out so that it would be easily calked. Probably the chief reason is that most shells these days are riveted by machine, the "Bull" as it is sometimes called, and this machine can not be used through a manhole.

3. What is wrong with an Ames engine on which the valve is groaning when more oil will not stop it?

A. Groaning of the valve may be caused by steam leaking between the pressure plate and the valve. This fault may be corrected by grinding the distance pieces. If this does not silence the groaning, it would be well to try a new oil.

4. What is wrong with a Greene engine under the same conditions?

A. Poor oil or a lack of sufficient compression would cause groaning on this type valve.

5. Why do the bell cranks on the side shaft of the Greene engine travel past center?

A. The object of having the bell cranks travel past center is to give the exhaust valves the necessary closing time.

6. How is cutoff equalized on the Greene engine?

A. Cutoff adjustment is effected by raising or lowering the toes of the valve mechanism. Care must be taken to see that they are not allowed to strike the sliding crosshead.

7. How do you change the lead on an Ames engine?

A. The lead may be adjusted by changing the position of an offset pin with which the valve actuating mechanism is equipped.

8. Why does an engine need compression?

A. Compression in a steam cylinder serves to cushion the piston, piston rod, crosshead, and connecting rod at the end of the stroke; and partially to balance the pressure on the steam valve.

9. Does the engine do any work on the steam end during the period of compression?

A. Work has to be done to compress steam just as work is done by the steam in expanding.

10. How does the governor on the Curtis turbine function?

A. The Curtis turbine may be governed by any one of three methods: the electrical, mechanical, which is usually used up to 1500 kw., and the oil pressure relay. In this method, which is used on large installations, the valves are operated through a piston and rock shaft by oil pressure. The valves are opened by pawls and closed by spring action.

11. How does the governor work on a Westinghouse Parsons turbine?

A. Admission on this turbine is through a double beat poppet valve which is controlled by an oil pressure operated piston whose action is in turn controlled by a pilot valve actuated by the governor proper. The governor is driven from a lay shaft which is driven through spiral gears from the main shaft.

12. How do the emergency trips on a turbine operate?

A. The emergency speed limiting device usually consists, in its elementary form, of a weighted pin moving in a guide radially out from the center line of the shaft. Centrifugal force tends to throw the pin outward, but at normal speed this motion is prevented by a spring. When the speed reaches a certain predetermined speed, however, the resistance of the spring is overcome and the pin moves out and trips a trigger cam which closes the main throttle valve. L. N. W.

Garage Heating

AN INTERESTING example of coincident results is presented in the answer to G. R. in the Dec. 1 issue, as compared with the results that follow. The question is not one of the factors used, for there may conceivably be room for differences of opinion on this point; it is the logical method of procedure that counts, and even though it were permissible to average the heat losses so that all the materials would be equal, there still remains some mistake.

In the first place the south walls are not exposed and therefore have no heat loss, while the answer given provides 60,000 B.t.u. for this, or an equivalent of 200 sq. ft. of pipe coil surface. In the second place the floor has no heat loss, because the ground on which it rests has a temperature of at least 50 deg., which means that there is no difference in temperature between it and the garage. The first answer, however, provides over 52 sq. ft. of heating surface for this purpose. Then after separate corrections have been made for weather exposure, another arbitrary addition of 30 per cent is made for leakage. This last item could be figured as

loss through cracks around doors and windows, plus ventilation, or taken on the basis of air change.

With these items taken care of, and assuming that the roof is of the same construction as the walls, the following results are obtained, showing that the roof in this case is the source of the greatest loss.

Item	Amount	Factor	Sq. ft. Radiation
Exposed walls = (37 + 70 + 57) × 15 = gross sq. ft.....2460			
Windows = (3.3 × 5.6) × 2 = 37	37	0.2	7.4
Doors = (15.5 + 14.3) × 12.5 = 373	373	0.05	18.7
Deduct 410			
Net wall exposed, sq. ft.....2050	2050	0.25	512.5
Roof = (42 × 37) + (28 × 57) = gross sq. ft. =.....3150			
Skylight as specified..... 392	392	0.2	78.4
Net roof exposed, sq. ft.....2758	2758	0.3	827.4
Cubic contents, based on 15 ft. average height = cu. ft.....	47,250	0.006	283.5
			1727.9
Add 15% for weather exposure =....	15%		259.1
Total coil surface radiation required equals, sq. ft.....			1987

These figures apply to the conditions stated in the problem for a temperature of 50 deg. with zero outside and using 1¼-in. pipe coils of the miter pattern, with steam at not over 2 lb. pressure.

In sizing up the boiler requirements, care must be taken to make appropriate allowance for piping and other losses. If an independent cast-iron sectional boiler is to be installed, it should have a rating of at least 3600 sq. ft. Should steam be taken from an existing line, figure the main for a load of at least 2800 sq. ft.

M. WILLIAM EHRLICH.

NOTE: In the original answer to this question it was assumed that the protection afforded the south walls was non-exposure to the cooling action of winds. It was also assumed that the ground temperature was below that of the garage and that the heat transmission was, as stated, 5 B.t.u. per sq. ft. Separate corrections were made on each wall, for exposure, as this item affects directly the rate of heat transmission through the walls. The correction of 30 per cent was made to allow for leakage, as stated, ventilation, and air infiltration through doors, windows, etc. The factors used represent an average of these used by such authors as Allan and Walker, Harding and Willard, Hubbard, etc. The method employed is due to Hubbard as expounded on pages 78 and 81 of his "Power Heating and Ventilation."

EDITOR.

Pipe Size

PLEASE GIVE me a formula for determining the size of pipe required to deliver a given quantity of steam at a given pressure in a given time. For instance, I want to know what size pipe I should use to deliver 200 lb. of steam per min. at a pressure of 90 lb. gage?

A. In determining the size of steampipe to be used in any given installation, either a maximum allowable steam velocity or a given pressure drop from boiler to engine must be assumed. For general reciprocating engine work, the steam velocity may be figured as about 6000 ft. per min. The better way, however, is to assume an allowable pressure drop. Originally this drop may be taken as from ½ to 1½ lb. per sq. in. per 100 ft. of length.

There are a number of formulas for determining the pipe size with this information given, which vary somewhat as to the constants used. The following, however, we think will fairly answer the purpose:

$$d = 0.203 \times \sqrt[5]{W^2 \, L \div P \, Y}$$

where d is the diameter, W is the weight of steam flowing in lb. per min., P is the pressure drop which we will take as one lb., L is the length over which this drop occurs in this case, 100 ft. Y is the mean density of the steam which at 90 lb. gage pressure is 0.2365. W, as given in the problem, is 200 lb. per min. Solving this equation, for d we find,

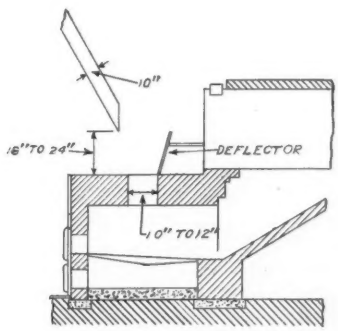
$$d = 0.203 \times \sqrt[5]{40{,}000 \times 100 \div 1 \div 0.2365} = 5.66 \text{ in.}$$

You of course would take the nearest commercial size and use a 6-in. pipe.

Wood Burning Stoker

N. T. ASKS ABOUT the handling of fuel to three 72-in. by 16-ft. horizontal return tubular boilers equipped with Dutch oven furnaces.

I would suggest that if the fuel was brought to the furnaces by gravity through a chute to each furnace, cut off above the feed hole as indicated in the sketch herewith, and the air eliminated through these chutes as much as possible, little or no trouble would be experienced from excess air or air blast through the feeder chute.



WOOD BURNING FURNACE

By arranging the chutes at an angle and cutting them off properly, any back draft would be prevented from going up the chute, as the explosion or blast out through the feed hole would not come near them. A second precaution should be taken, in that the damper should be arranged so that it could not close absolutely tight, or tight enough to prevent the air always passing through the furnace in a direction in, rather than out through the feed door. If, for any reason, it was necessary to check the fires more than could be handled by the main damper, this should be done by the damper on each individual boiler. This method has been successfully tried by me in one or two plants and has shown a great improvement in efficiency as well as in cutting down the destruction of the furnace lining.

HENRY D. JACKSON.

POWER PLANT ENGINEERING

Trade Mark, Reg. U. S. Pat. Office

Issued the 1st and 15th of each month. Established over 25 yr.

Published by the TECHNICAL PUBLISHING CO.

537 South Dearborn Street, Chicago.

New York Office, 150 Nassau St.

Subscription price $2.00 a year in postal zones 1, 2, 3, 4 and 5, which include all postoffices within a distance of 1400 miles from Chicago.

Subscription price $2.50 a year in postal zones 6, 7 and 8, which include all postoffices more than 1400 miles from Chicago.

Copies, current issue, 15 cents; back numbers, 25 cents.

Notify us at once of any change of address, giving the old and the new address, so that your paper may always reach you promptly.

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Entered as second class matter May 1, 1908, at the Post Office at Chicago, Illinois, under the act of March 3, 1879.

Member, Associated Business Papers.
Member, Audit Bureau of Circulations.

Circulation of this issue, 23,000

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Assure Your Coal Supply

Coming from Secretary Hoover is the statement that "a strike in the bituminous coal fields beginning March 31 appears to be inevitable." It appears that the United Mine Workers are demanding a renewal of the present wage terms, while the operators of unionized mines positively assert that they will not renew the present wage contracts and that they cannot continue to operate except on the basis of a lower wage scale.

About 30 to 40 per cent of the mines are not unionized and it is the opinion of the administration that with these in operation and the reserve stocks of coal on hand there will be no danger of a railroad tie-up for several months. Reports indicate, however, that industry in general is preparing for a protracted mine strike.

Of course nobody knows just what course events will take, but it behooves every power plant engineer to be on the safe side with plenty of fuel in storage to tide over any such contingency as a coal miners' strike. To aid the engineer in deciding upon the amount of coal to store away for this emergency use, the editors of Power Plant Engineering are collecting data relative to the duration and extent of coal miners' strikes in the past, coal production during the past few years and the amount of coal held in storage at different dates. This information will be presented in the February 15 issue, together with what other data relative to the subject can be compiled.

90 Per Cent Boiler Efficiency

No other unit in the power plant is so subject to widely varying operating conditions as the boiler and its furnace. Each new delivery of coal brings with it slightly if not greatly different characteristics from that which has just been used. Air is continually changing in temperature, humidity and barometric pressure. The fuel bed, even with the best of stokers, is far from a homogeneous mass, constantly changing as combustion proceeds, developing blow holes here and there, but always shifting in location; clinkers form and attach themselves to the grates on walls of the furnace. Air leaks through hair-like crevices in boiler walls and develops larger holes continuously with increasing heat losses. Soot and scale accumulate to retard the transmission of heat from furnace gas to water. Then the demand for steam varies and whatever adjustments of stoker, air and water supply may have been made correctly to suit the former load are now all upset and the fireman must start in again.

Under such conditions, particularly where hand regulation is depended upon, most engineers are quite content if they secure an over-all boiler efficiency of 70 per cent with an occasional streak of good fortune bringing it up to 75 per cent. A new standard, however, has been set by Mr. Azbe at 90 per cent, this he considers possible and practicable with modern equipment, but frankly states that the required conditions are severe, requiring a setting which will give complete combustion with only 15 per cent of excess air and a flue gas temperature not to exceed 250 deg. F., which, of course, precludes the use of an economizer.

Based on theoretical calculations modified by practical experiments, this standard should be taken seriously as an attainment which can be reached in practical oper-

ation. Although we have on record but one test which comes up to this standard, there are a number of plants in which the boiler efficiency attained in daily operation is around the 85 per cent mark, and this is gradually being increased so that 90 per cent is not an idle dream nor a general statement.

To reach such a standard there must be no guesswork in maintaining related conditions, for the slightest variations from the ideal will have their detrimental effects and under such conditions instruments must have a precision approaching closely that necessary for scientific investigation; the equipment must of course be designed for the required conditions, fuel and water must be selected and prepared with utmost care, and above all the personnel of the boiler room force must be competent, vigilant and work in harmony. The way is now open to higher boiler efficiencies and 90 per cent is certainly a goal worth striving for.

Power Plant Slogans

Keep and Analyze Operating Records in Every Power Plant.
Develop Water Power Sites.
Promote Health and Safety in Power Plants.
Handle Coal and Ashes Mechanically.
Employ Engineers for Engineering Work.

Self-Expression in Industry

Man is essentially a creative animal. Because of that fact he has become civilized; or, expressing it in other words, his civilization is a product of his own creation. From the very earliest stages of his development from the lower forms of life, this power of creation has characterized his entire progress. When in the rude shelter of his cave, paleolithic man first drew sparks from a piece of flint and created fire, the event marked the first milestone in his climb towards higher civilization. In the ability to create fire for his use and comfort, man first displayed his superiority over the beasts with which he was engaged in the fierce struggle for existence. Later, when by means of pictures and signs chiseled out on the rough walls of his cave, he left a record of his existence for following generations to read, he created another powerful factor in advancing his own civilization. By means of these pictures and signs he was able to give others that followed the benefit of his creative efforts and from that time on the effects of those efforts were more or less accumulative. Thus he has always been and thus he is today, a creative animal. It is his inherent nature and anything that might act to oppose this characteristic or limit its freedom of expression is detrimental to his development.

The world is changing—methods are changing. New methods are being introduced in industry and modern methods of manufacture have little in common with those of fifty or a hundred years ago. Labor-saving machinery is being introduced in all industrial operation and attempts are being made to stimulate the industrial productivity of the workers by various means. The all-around mechanic or the general machinist, who could make anything on a lathe from a nut cracker to a steam engine, is rapidly disappearing. In his place we have a crack automatic machine operator who turns a groove in 297 standardized wrist pins, designated part No. 416 of a certain automobile engine every hour. All he does, all day long, eight hours a day, six days a week, is to feed in blanks, manipulate three or four levers with almost automatic rhythm and precision and watch 297 partly finished wrist pins drop into an automatic conveyor every hour. His motions are as predetermined and regular as though actuated by a cam or connecting rod on the machine which he operates. In this manner he wears out his drab existence. He has no opportunity to display any originality—he has no recourse to varying the monotony of his work by doing it in a slightly different manner—he has only one thought, that of serving the machine. The creative element has gone out of the work.

To the shoemaker of former days who from the leather as raw material made a complete pair of shoes, to the machinist who collaborated in building a finished machine, there was a satisfaction in the creation of things which necessarily gave them an interest in their work. To the engineer who has complete charge of the engine and boiler rooms, who knows every pipe and valve in the entire power house, though his work may be strenuous at times and the hours long, it nevertheless holds much of interest for him. In the large modern power station where the operating man has charge, perhaps, of only a turbine-driven feed pump or a condensate pump of one of the main turbines, conditions are different. He, like the automatic machine operator, also becomes part of the machine which he tends with practically no opportunity for exercising his creative instinct.

Even the chief operator in a power plant of the larger type can display little discretion and handles the machines and switching apparatus only upon orders from the "load dispatcher." Of course, we do not wish to convey the impression that the chief operator's job is unimportant or uninteresting, but the illustration serves to indicate that modern methods are far-reaching in their effects towards standardizing human operations.

The old feeling of craftsmanship, which existed before the industrial revolution came about, is rapidly disappearing because of the perfection reached in machine design. The result is that today men's work tends to become mere toil. It degrades the industrious man, thrilling with energy, into a work-shy slacker; he begins to look for shorter hours and becomes generally dissatisfied. Men and women will work if they feel like working, but if they do not, they simply sabotage whether consciously or unconsciously.

It is obvious, therefore, that something will have to be done to overcome these ill effects of automatization and mechanization of industry. The workers' inherent need for self-expression must be satisfied.

How this may be accomplished is, obviously, a difficult problem and considerable thought has been given the subject by certain individuals. In the pages of this issue Walter N. Polakov throws some light on the subject, and his article should prove of interest to everybody interested in the development of the human race.

The Industrial Stoker

AMONG the distinctive features of the Industrial stoker, which has just been placed on the market by the United Machine & Mfg. Co. of Canton, O., is the design of the grate which is a combination of ribbed and perforated grates placed alternately and parallel with step-shaped air distributing grate bars.

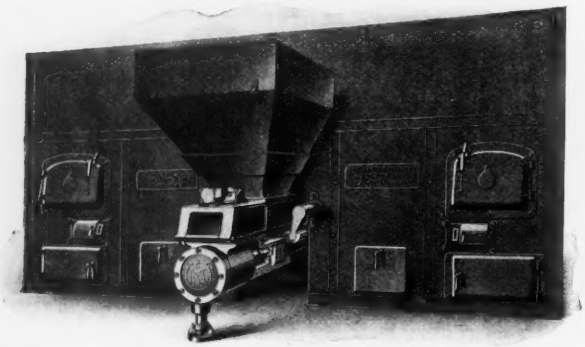


FIG. 1. FRONT OF INDUSTRIAL STOKER

By the latter arrangement air is delivered to the fuel bed in a horizontal plane and with the fuel moving continuously down the inclined surface blow-holes are not formed, consequently a uniform distribution of air is obtained throughout the fuel bed.

The principle of operation is essentially that of a single retort under-feed stoker which delivers incandescent coked coal to double inclined forced draft grates

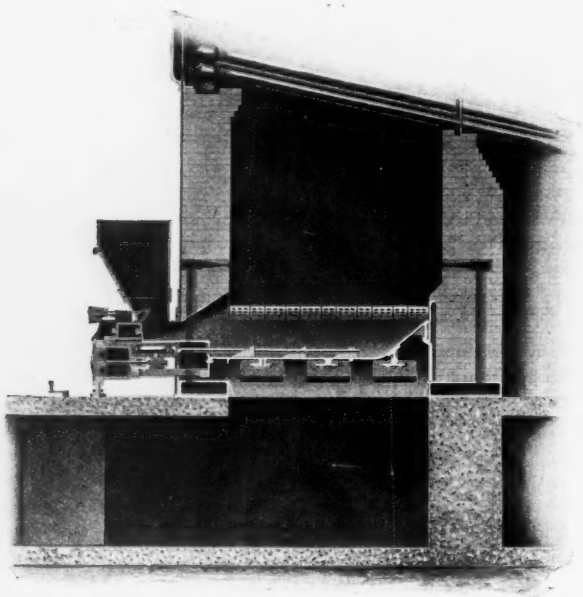


FIG. 2. LONGITUDINAL SECTION SHOWING RAM MECHANISM AND DUCTS FOR INTRODUCING AIR INTO FURNACE

extending along the sides of the retort. The movement down the grates is caused principally by gravity, but is assisted by reciprocating tuyere heads. Air for complete combustion is delivered to the blast box below the retort and that necessary for combustion of the volatile constituents in the fuel passes through the tuyere heads on the sides of the retort, while the air used in the secondary zones of combustion passes through regulating dampers to the under side of the grates, thence through the fuel bed. An auxiliary air supply is also introduced over the fuel bed through tuyeres in the furnace walls as shown in Fig. 2. Thus air is supplied in proper volume to the different zones of the stoker and furnace.

Any desired speed of the ram delivering the coal to and distributing it in the retort may be obtained by readily adjusted mechanism. Lateral distribution from the retort is accomplished by means of the reciprocating tuyere heads which are readily adjustable to speed and length of stroke while the stoker is in operation. This provision gives an opportunity to keep the fuel bed in proper condition with coals having different characteristics.

Under ordinary load conditions the moving parts of the stoker operate simultaneously, but provision is also made for continued operation of the ram without the movement of the reciprocating tuyere heads and perforated grate bars.

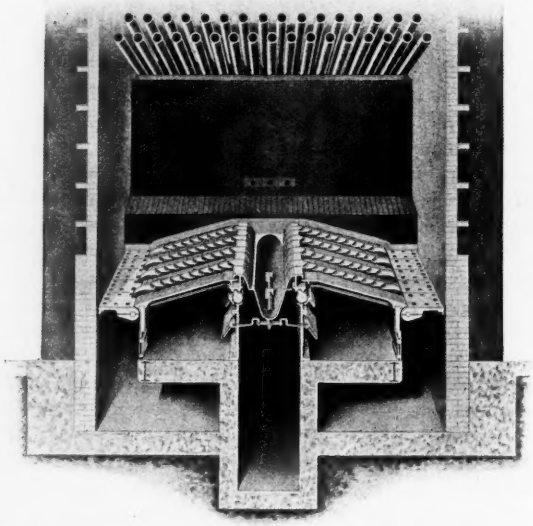


FIG. 3. CROSS SECTION OF INDUSTRIAL STOKER AND FURNACE

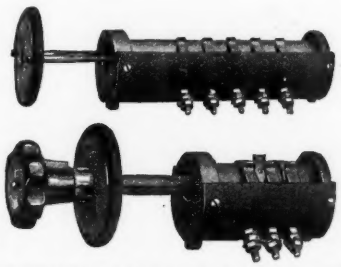
Simultaneous adjustment of fuel and air supply according to load conditions is accomplished automatically by means of an oil control system.

The accumulation of ash along the side walls of the furnace is relieved by dropping the dump plates, thus discharging the ash to the ashpit for removal by means of the regular conveying system or any other means provided.

Compact Instrument Switches

FOR CONNECTING one instrument to any one of several circuits, and for making the multipoint connections required when synchronizing generators, the Westinghouse Electric & Manufacturing Co. is marketing the type of instrument switch shown in the accompanying illustration. With the exception of the ammeter and the thermo couple-switches, these switches have removable keys or handles, so labeled and con-

structed that they cannot be inserted in the wrong switches. In construction, ruggedness and compactness are the salient features. Movable contact members, securely mounted on a substantial bakelite-micarta drum engage with stamped contact fingers as the drum is rotated to the right or left. The switching element is housed in a substantial bakelite-micarta tube. A segment of the housing is easily removable for inspection and adjustment.



DRUM-TYPE SWITCHES ALLOW USE OF ONE INSTRUMENT FOR SEVERAL CIRCUITS

The types of switches in this line are as follows: ammeter switch, thermo-couple switch, voltmeter switch, frequency meter switch, wattmeter, watthour meter, power factor meter and reactive factor meter switch, synchronizing switch for synchronizing between machines, synchronizing switch for synchronizing between machine and bus, and multi-circuit volt-meter switches.

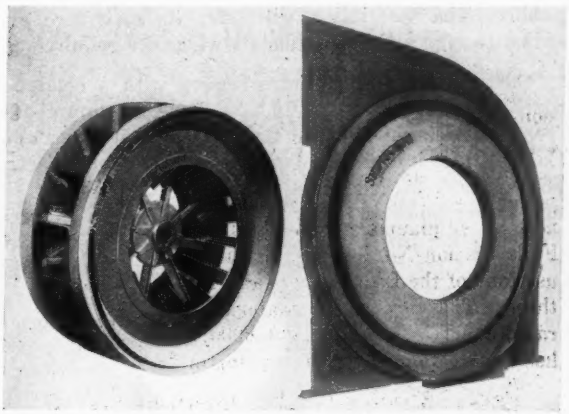
Induced Draft Fan For Catching Cinders

BUCKETS provided at the inlet edges of induced draft paddle wheel fan blades are employed by the B. F. Sturtevant Co. in a recently designed fan for catching cinders that would otherwise be blown to the atmosphere through the stack. To remove the cinders from the buckets inclined channels are provided leading out into special dust chambers in the fan in which the dust settles. The dust chambers lead to closed hopper from which cinders can be removed periodically or continuously by means of screw or other conveyors. The illustrations show the inclined channels and the dust chambers. Guiding vanes will be noticed which serve to direct the air and cinders into the inclined channels.

It was found that this cinder separating fan could be built without taking up any more room and without requiring any more attention than an ordinary induced draft fan. As a fan it proved more efficient than the average induced draft fan in the market and as a separator it was found, on test, to remove 75 per cent of the solid matter in the gases. Naturally the fan removes a much larger percentage than this of the heavy, coarse material, and it is this heavy, coarse material which drops over the city in the neighborhood of power plants, causing numerous complaints from the residents in that section.

Two large fans were installed in connection with six 500-hp. boilers and when these boilers were operating at 200 per cent of rating it was found that each fan was removing 250 lb. of cinders per hour. The material separated at this plant resembled a fine coke breeze and showed on analysis some 9700 B.t.u. per pound. It is estimated that the wheel will last as long as the wheel of an ordinary induced draft fan because the latter is subject to the same abrasive action caused by the cinders against the blades. The housing of the fan will last longer because a part of the cinders never reach the fan housing. The only place where there is any wear is in the cinder chamber of the fan housing. These cinder chambers are provided with easily removable wearing strips of simple forms.

This fan can be adapted to collect many other kinds of materials. The B. F. Sturtevant Co. maintains an experimental fan in its research laboratory which is used constantly for trying out new materials which are



ROTOR AND CINDER CHAMBER OF CINDER CATCHING FAN

sent in. In this way is determined the amount of separation that is possible to secure from the fan and also to design accurately the proper size fan for each particular problem which they have to meet.

News Notes

AFTER SEVERAL years of thought and discussion along similar lines, the movement for the affiliation of the architectural, engineering and other technical societies of Detroit was taken up seriously in June, 1921, by the organization of a temporary council composed of two delegates from each of the several societies interested. The affiliation has become an accomplished fact, taking effect Jan. 1, 1922, by the ratification of the proposed constitution and by-laws, under the name Associated Technical Societies of Detroit, acceptance of membership and election of councillors by the following 12 societies: Detroit Section, American Society of Civil Engineers; Detroit Chapter, American Association of Engineers; Michigan Chapter, American Society of Heating and Ventilating Engineers; Detroit Post, Society of American Military Engineers; Detroit Section, American Society of Mechanical Engineers; Detroit-Ann Arbor Section, American Institute of Electrical Engineers; American Institute of Chemical Engineers; Detroit Engineering Society; American Chemical Society and Detroit Chemists; Michigan Chapter, American Institute of Architects; Detroit Section, Michigan Society of Architects; Detroit Chapter, American Society of Steel Treating.

The permanent council met and organized Dec. 13, 1921, and elected officers for 1922 as follows: Chairman, P. W. Keating; vice-chairman, A. A. Meyer; secretary-treasurer, Walter R. Meier. A central office will be established for conducting the business of the several societies and will schedule the dates of meetings of all the technical societies.

The paramount use of the new association to its members and to the public is its opportunity for public service both for the city of Detroit and for the State of Michigan. The association will take an active interest in all matters wherein engineering, architectural and technical subjects are an important factor. The council will study the opinions of the membership and will assist in furnishing definite and accurate information to the public. The association will offer its assistance and advice to city and state officials whenever required.

SEVEN HIGH voltage transformers with a combined continuous rating of 162,975 kv.a. have been purchased from the General Electric Co. by the Southern Power Co. for the initial development of the hydroelectric power plant at Mountain Island, N. C., and for the new power plant at Great Falls, S. C., known as Great Falls Station No. 2. The Mountain Island station will use four of the transformers and the Great Falls station three. They are of the water-cooled three-phase type rated at 18,750 kv.a. 101, 200-6600 v. Each transformer has a maximum continuous rating of 23,425 kv.a.

FRANK KIERNAN & Co., advertising agency, 135 Broadway, New York, has opened a business paper department under the personal direction of Alfred N. Williams. Mr. Williams, formerly of the Fairchild publications, and with an experience of 17 yr. in trade paper and advertising agency work, declares that this department will accept as clients only those who will use the business papers as their basic advertising.

ANNOUNCEMENT is made that the Steam Motors Co., of Springfield, Mass., has sold all its assets, patents and interests to the London Steam Turbine Co., of Troy, N. Y. Mr. London, who was the president of the Steam Motors Co., will occupy the same position with the London Steam Turbine Co. Mr. De Leon will be vice-president and general manager.

C. H. DAVIES has severed his connection with the S. F. Bowser Pump & Tank Co., with whom he has been associated for the past 16 yr., and has taken up new duties with the Citrus Products Co., of Chicago, having charge of advertising and marketing.

A. R. ST. JOHN has been appointed manager of the New York office of McClave-Brooks Co. He succeeds S. G. Smith whose resignation took effect on Jan. 1, after more than 20 yr. service in this territory. St. John was formerly in charge of the Boston office of the McClave-Brooks Co.

PENNSYLVANIA PUMP & COMPRESSOR CO., Easton, Pa., has issued a new bulletin covering Pennsylvania single-stage, straight line, air compressors and vacuum pumps in both belt and steam driven types, and complete as to tables of standard sizes, etc.

W. S. ROCKWELL CO. announces that Gibbons Bros., Ltd., Dudley, Worc., England, has been appointed as representative of the company for the British Isles.

B. W. THURTELL has been appointed district sales agent for the Ames Iron Works with offices at 22 West Quincy street, Chicago, Ill.

G. A. BINZ, assistant sales manager American Steam Gauge & Valve Manufacturing Co., Boston, has been appointed sales manager of that company effective Jan. 1, 1922.

H. W. CROSS, formerly of the General Electric Co., has assumed management of the New England office of C. H. Wheeler Manufacturing Co. with headquarters at 53 State St., Boston Mass.

THE STOCKHOLDERS of the Nashua Machine Co., Inc., on Dec. 31, 1921, voted to change the name of the corporation to Bundy Steam Trap Co. The change became effective at the close of business Dec. 31, 1921.

ENGINEERING salesmen of Detroit have formed an organization to promote a higher grade of salesmanship and to conduct an educational campaign among the members and prospective buyers. The Detroit Supply Club will hold a luncheon meeting on the first and third Fridays of each month to hear addresses from sales specialists of Detroit and other cities. Headquarters are in the Board of Commerce. Officers and charter members are: President, E. J. Garant, Buckeye Chemical Co.; vice-president, E. L. Stecker, Stecker Motor & Packing Co.; and treasurer, John Trix, Jr., American Armature Co.; secretary, S. R. Bowen, The Garlock Injector Co. The charter members are: Buckeye Chemical Co., E. J. Garant; The Garlock Packing Co., S. R. Bowen; Coon-DeVisser Co., W. A. Starrett; J. T. Wing & Co., B. F. Mathews; Republic Flow Meters Co., F. A. Furlong; Crane Co., C. R. Gross; A. Harvey's Sons Manufacturing Co., E. L. Stecker; American Injector Co., John Trix, Jr.; Standard Oil Co., D. R. McDuffy; Sarco, Inc., G. Frank Gordner; H. W. Johns Manville Co., J. Edw. LaFrance; Westinghouse Electric & Manufacturing Co., Mr. Crocker; Power Plant Specialties Co., Mr. VanTassel; H. D. Edwards & Co., Robert Fox; Holmes-Michael Electric Co., F. H. Holmes; Bryant Engineering Co., W. B. Bryant; Greenslade Oil Co., George Bohnsack; The Chas. A. Strelinger Co., Walter J. Frey.

Catalog Notes

SYLPHON temperature regulators for air, liquids and gases are described and illustrated in a folder from the Fulton Co., Knoxville, Tenn.

INDUSTRIAL WORKS, Bay City, Mich., is distributing Catalog No. 113, illustrating and describing the Industrial crawling tractor cranes of 20,000 lb. capacity.

THE "EV" type of alternating current, vertical water wheel driven generators is described and illustrated in Circular 3439, recently issued by the Westinghouse Electric & Manufacturing Company. The vertical unit has been recognized as the most practical arrangement for the small and moderate capacity low head hydroelectric plant and the type "EV" comprises a line of a.c. generators, especially laid out with the requirements of economy in first cost and performance, of design, proportions and arrangements to fit the modern hydraulic setting and the same factor of safety in design and reliability in operation required of larger units.